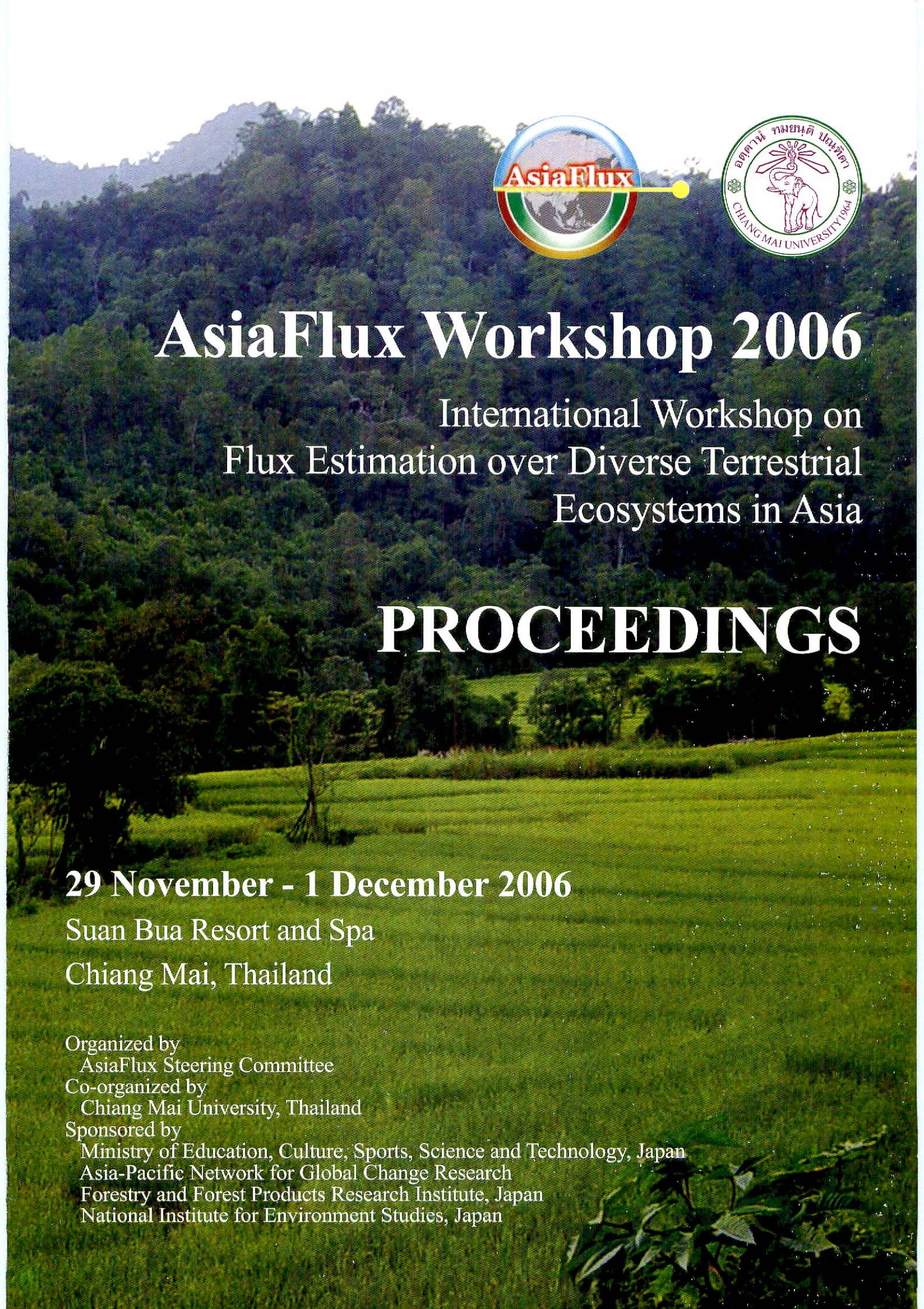

AsiaFlux Workshop 2006

International Workshop on Flux Estimation over Diverse Terrestrial Ecosystems in Asia

PROCEEDINGS

29 November - 1 December 2006

Suan Bua Resort and Spa

Chiang Mai, Thailand

Organized by
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Co-organized by
Chiang Mai University, Thailand
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Ministry of Education, Culture, Sports, Science and Technology, Japan
Asia-Pacific Network for Global Change Research
Forestry and Forest Products Research Institute, Japan
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S01

PRESENT SITUATION AND CHALLENGES OF ASIAFLUX - FROM ACTIVITIES OF WORKGROUPS IN 2006 -

Y.Ohtani[1], J. Kim[2], Y. Fujinuma[3], K. Hirano[4], D. Lee[2], A. Miyata[5], N. Saigusa[6] and M. Tani[7]

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We have introduced last year, at the 4th AsiaFlux Workshop held in Fujiyoshida, Japan, about our plan on building the Asian regional flux network along the frame work of projects "Initiation of the next-generation AsiaFlux (MEXT)" and "Standardization and Systematization of Carbon-Budget Observation in Asian Terrestrial Ecosystems Based on AsiaFlux Framework (APN)". After the Workshop, we have situated two workgroups with three sub-workgroups under each workgroup, in the AsiaFlux organization (Ohtani, 2005). We are steadily carrying out our activities, and these AsiaFlux workgroups play important roles in its implementation.

One of the most topical and fruitful activities in this year was the very first AsiaFlux Training Course on Micrometeorology, organized by *Short Training Course Sub-workgroup*. The training course aimed for diffusing basic theory and observation techniques to Asian flux researchers. More than twenty participants who were about to start carbon dioxide flux measurement joined from ten different countries (Saigusa *et al.*, 2006). We believe this training course has contributed to extend the carbon dioxide flux observation in Asia, and to improve data quality and fostering leading researchers. Above all, cooperative relations among Asian research institutions we developed through the course is a great hoard to AsiaFlux community.

AsiaFlux Editorial Sub-workgroup has issued five volumes of AsiaFlux Newsletter in the updated editorial line. In these issues, five editors from Korea and Japan compiled 21 articles from Korean, Chinese and Japanese authors. Contributions from wider district in Asia are expected, along with the further intensification of our activities.

In parallel with these on-going activities, we are discussing AsiaFlux policy and membership to be taken in context. We have not updated those descriptions in our web site since the establishment of AsiaFlux in 1999. The AsiaFlux executive and steering committees are conducting comprehensive deliberations on these matters, suggested by *Network Management Sub-workgroup*. One important issue is to situate AsiaFlux to be an umbrella organization which covers Asian communities who carry out observations on carbon dioxide, energy and water vapor flux or terrestrial carbon.

Moreover, *Database and Data Policy Sub-workgroup* has begun to discuss the AsiaFlux database policy and updating site information. *Measurement Support and Standardization Sub-workgroup* has also started the development of standardized flux measurement systems. Some workgroup members have suggested us that we have to reconsider the current linkage among each subgroup activities. We intend to improve AsiaFlux to be more accessible and attractive with a cooperation of participants who join to AsiaFlux.

Acknowledgements: *We would like to thank all the collaborators in AsiaFlux sub-workgroups for promoting our activities. The AsiaFlux activities were financially supported by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) and by the Asia-Pacific Network for Global Change Research (APN).*

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Ohtani, Y. 2005. AsiaFlux implementation of New Programs funded by MEXT and APN, AsiaFlux Newsletter 15, 1-2.

Saigusa, N., Takagi, K., Yuta, S. and Hirata, R. 2006. Report on the AsiaFlux Training Course 2006, AsiaFlux Newsletter 19, 1-2.

FLUXNET AFTER 10 YEARS: SYNTHESIZING CO_2 AND WATER VAPOR FLUXES FROM ACROSS A GLOBAL NETWORK

M. Falk[1] and D.D. Baldocchi[2]
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FLUXNET is a global network of micrometeorological flux measurement sites (Fig. 1) that measure the exchanges of carbon dioxide, water vapor, and energy between the biosphere and atmosphere. Over the past ten years, the FLUXNET project has grown from a handful of sites that are continuously measuring carbon dioxide and energy fluxes to over 400 sites worldwide (Fig. 2). With an extended dataset overlapping the duration of the TERRA and AQUA satellites, the FLUXNET project is poised to address the next generation of carbon cycle questions. The overarching goal of FLUXNET is to quantify spatial/temporal variations of terrestrial carbon dioxide exchange, as assessed with a global network of eddy covariance flux measurement towers, and relate this information to carbon fluxes being deduced from remote sensors on satellites and towers.

Fig 1. Distribution of flux tower sites (October 2006)

Specifically, the FLUXNET project has collected a large amount of data from a spectrum of canopy roughness conditions, functional types and climate spaces provided by regional networks and investigators. FLUXNET can be seen as a model for data sharing in the scientific community. FLUXNET has sponsored collaboration and synthesis through workshops, hosting visitors and has helped in building a collaborative, cooperative, multi-disciplinary and international community of researchers.

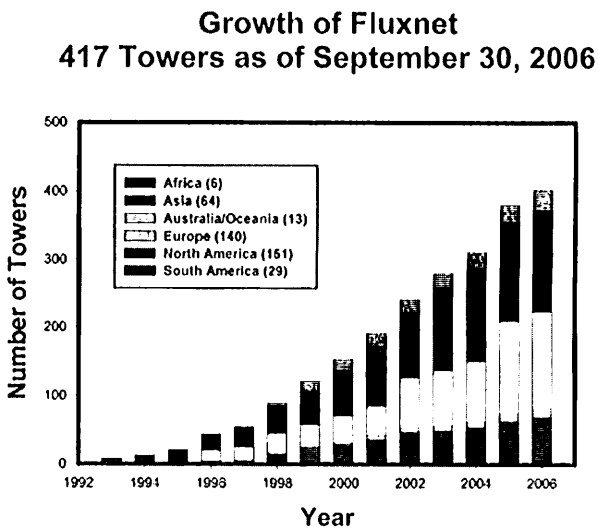

Fig 2. Number of flux tower sites

The FLUXNET project produces gap-filled, value-added databases of carbon flux measurements. These data provide the experimental foundation for improving and testing algorithms that assess gross primary productivity (*GPP*) and net primary productivity (*NPP*) using remote sensing data and normalized vegetation indices (Fig. 3) and validating and improving SVAT models used for weather, climate, biogeochemistry and ecosystem dynamics.

The intrinsic value of flux networks on regional and global scales lies in their ability to produce large and long-time data sets, reduce sampling error, create robust datasets for model development, capture pulses and lags of ecosystem processes, study the gradient of climates, structure and function, and provide for better integrated research studies.

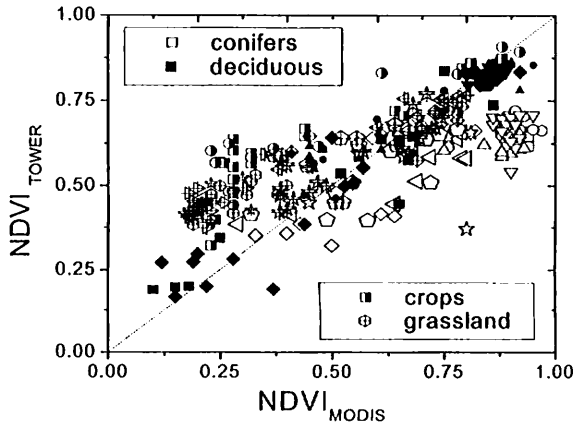

Fig 3. A broadband tower NDVI plotted against MODIS NDVI for 14 FLUXNET sites

O11

NEW DEVELOPMENT IN CANOPY-ATMOSPHERE EXCHANGE

M. Y. Leclerc[1],J. Hong[1], G. Zhang[1], A. Andrews[2],R. Avissar[3], P. Bertsch[4], W. Eichinger[5], M. Parker[6], G.Qiu[7], J. Warland[8] and T. Watson[9]

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This paper introduces the concept of a Carbon Flux Super Site, the next-generation of flux sites aimed at characterizing carbon exchange between terrestrial ecosystems and the atmosphere. The Carbon Flux Super Site harnesses cutting-edge technologies to generate insights leading to highly relevant biological and physical process information about the carbon cycle. It does so in a concentrated, integrated effort, so that comprehensive novel measurements related to carbon exchange in non-ideal conditions result in more scientifically credible data.

Using recent methods to characterize the impact of frequent and poorly documented atmospheric phenomena on carbon fluxes, this Carbon Flux Super Site aims at producing revised, more robust regional-scale carbon fluxes. This data is obtained using both stationary and airborne flux platforms combined with onsite tall tower CO_2 mixing ratio measurements. The data will be used as input into regional models to simulate more accurate climate change scenarios that result from increased atmospheric CO_2 concentrations.

The second portion of this talk reports on the latest developments surrounding canopy-atmosphere exchange. A recent Lagrangian diffusion method is used to examine the canopy-atmosphere gaseous exchange for sources vertically distributed within the canopy layer. We examine the validity of the Lagrangian diffusion method and discuss the behavior of the diffusing scalar as a function of distance from the in-canopy sources/sinks, both for the near-field and for the far-field. It mimics the diffusion of CO_2 respired from the soil surface, and the diffusion of gases exchanged separately from the main canopy layer and from the understory. The influence of buoyancy forcing on the results is discussed. These results spark new understandings on gaseous transport inside forest canopies and its exchange of gases between the canopy layer and the atmosphere.

O12

SYNTHETIC ANALYSIS OF THE LONG-TERM CARBON BUDGETS ESTIMATED FROM TOWER-FLUX MEASUREMENTS AT VARIOUS FORESTS IN EAST ASIA

S. Yamamoto[1], N. Saigusa[2], R. Hirata[3], R. Ide[3], Y. Ohtani[4], M.Tani[5], Y. Kosugi[5], M. Gamo[2], H. Wang[2], H. Koizumi[6] and Y. Fujinuma[3]

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The elucidation of the carbon budgets at various ecosystems has become an important subject of the global warming issue. Especially, forests have a key role in the global carbon cycle, sequestering large amounts of atmospheric CO_2. However, the ability of carbon sequestration depends on the type of forests and climate conditions. The environmental conditions in East Asia under a monsoon climate differ from North America and Europe. The precipitation in East Asia is larger than that in these continents, in particular, the much precipitation in the mid-latitude. Due to the specific features of climate and forest type, the carbon budgets in East Asia should be different from those of North America and Europe.

From this point of view, in this lecture, the preliminary results of long-term carbon budgets at forest sites in East Asia are explained and discussed about following points: (1) Annual-integrated values of carbon budget and their relation with meteorological conditions, (2) Comparison of the results of Net Ecosystem Production (NEP) with each other in East Asia and with NEP values in American and European forests and (3) Quantitative evaluation of NEP by the eddy covariance method through comparison with biometric estimation of NEP.

Table 1: Annual-integrated values of NEP, RE, GPP (gC/m^2/year), NEP/GPP, Mean Air Temperature (degC), PPFD(mol/m^2/year) and Precipitation(mm/year) (from data-base of S1 project, *: without u*-correction)

Site (degN, degE)	Years	NEP	RE	GPP	NEP/GPP	Air Temp.	PPFD	Precip.
Takayama, Japan (36.1,137.4) (deciduous broad-leaf forest)	2000-04	337	882	1219	0.28	7.3	9900	2400
Fujiyoshida, Japan (35.5,138.8) (evergreen needle-leaf forest)	2000-04	489	1059	1548	0.32	9.5	10466	1506
Kiryu, Japan (35.0,136.0) (evergreen needle-leaf forest)	2001-04	554	1471	2025	0.27	15.1	9146	1500
Tomakomai, Japan (42.7,141.5) (deciduous needle-leaf forest)	2001-03	177	1502	1679	0.11	7.7	8529	1247
Laoshan, China (45.3,127.6) (deciduous needle-leaf forest)	2004	121	1227	1348	0.09	2.8	---	724
Pasoh, Malaysia (3.0,102.3) (tropical rain forest)	2003-05	854*	---	---	---	26.3	12967	1733
Sakaerat, Thailand (14.5, 101.9) (tropical seasonal forest)	2003	1283*	1543*	2826*	0.46*	24.3	14570	1750

Acknowledgements: *This study was supported by Japan Ministry of Environment (S1 project: Integrated study for terrestrial carbon management of Asia in the 21st century based on scientific advancements). The authors would like to thank all the project investigators, their co-workers, and students for providing data.*

O13

TEMPORAL AND SPATIAL VARIATIONS IN THE SEASONAL PATTERNS OF CO_2 FLUX IN BOREAL, TEMPERATE, AND TROPICAL FORESTS IN ASIA

N. Saigusa, [1] S. Yamamoto, [2] R. Hirata, [3] R. Ide, [3] M. Gamo, [1] T. Hirano, [4] Y. Kosugi, [5] S. -G. Li, [6] Y. Nakai, [7] Y. Ohtani, [7] T. Oikawa, [8] M. Tani, [5] and H. Wang [1]

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Measurements of the net ecosystem production (NEP) over forest stands were conducted from flux towers in boreal, temperate, and tropical regions in East Asia from 2000 to 2005. The sites are distributed over a wide latitude ranging from 3 to 64 °N and include boreal and temperate needle-leaf deciduous forests (larch) (central Siberia, Mongolia, China, and northern Japan), temperate broadleaf deciduous and needle-leaf evergreen forests (central Japan), and tropical rain forest and seasonal forest (Malaysia and Thailand).

The boreal larch forests had short growing periods of 3-4 months. The temperate deciduous sites showed the greatest positive NEP in early summer, after leaf expansion. The temperate evergreen sites showed earlier positive NEP in spring than the deciduous sites and had long growing periods (> 10 months). The tropical rain forest showed a small flux throughout the year without a clear seasonal change.

In 2002 and 2003, several significant weather anomalies were observed, such as positive temperature in the temperate sites in the 2002 spring, negative precipitation in the tropics in 2002, and negative solar radiation in the temperate sites in the 2003 summer. The seasonal patterns of NEP were sensitive to the anomalies, and the variations were caused by (1) high spring-air temperature, which induced an early start of the growing period in the temperate sites, (2) summer solar radiation, which controlled the annual gross primary productivity; (3) and a long dry season, which affected the leaf area index and NEP in the tropical seasonal forest.

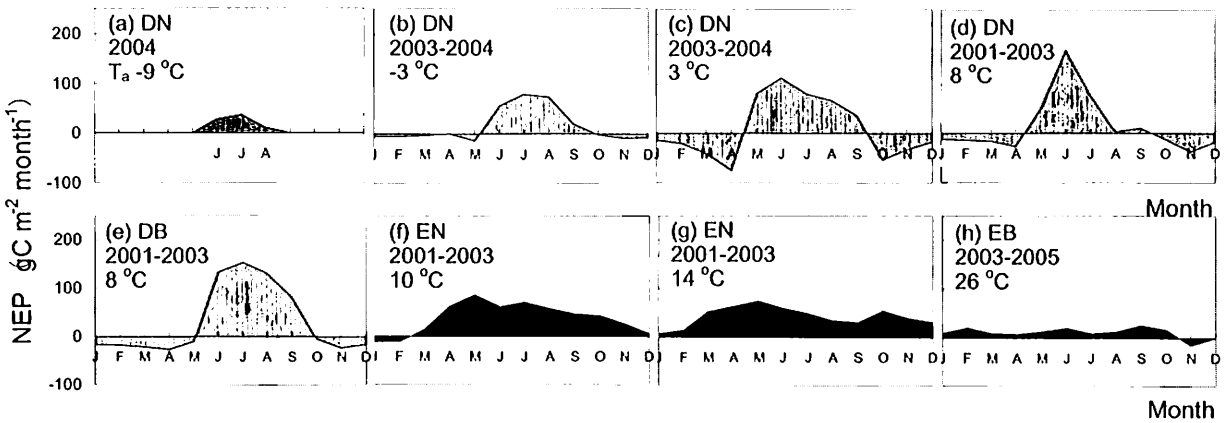


Fig. 1. Monthly NEP observed in (a) boreal larch forest in central Siberia; (b) boreal larch forest in Mongolia; (c) temperate larch forest in northeastern China; (d) temperate larch forest in northern Japan; (e) temperate birch-oak forest in central Japan; (f) temperate red-pine forest in central Japan; (g) temperate cypress forest in central Japan; and (h) tropical rain forest in Malaysia. The symbols DN, DB, EN, and EB indicate deciduous needle-leaf, deciduous broadleaf, evergreen needle-leaf, and evergreen broadleaf, respectively. The year(s) of NEP evaluation and annual air temperature (T_a) are indicated in each figure.

Acknowledgements: *This study was supported by the Japan Ministry of the Environment (Integrated study for the terrestrial carbon management of Asia in the 21st Century on the basis of scientific advancements). The authors would like to thank all the project investigators, their co-workers, and students for providing data.*

O14

THE SPATIAL AND TEMPORAL DISTRIBUTIONS OF THE ENERGY PARTITION ABOVE FORESTS IN MID- AND HIGH-LATITUDE REGIONS

–Analyses using the AmeriFlux, EuroFlux, and E. Eurasia-Japan datasets–

T. Ohta

Nagoya University, Nagoya, Japan

Introduction

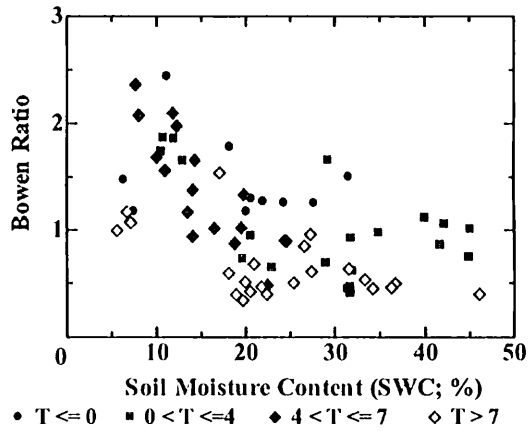
Water, energy, and carbon dioxide exchanges have been examined intensively at many sites on the globe in the last decade, and site-specific characteristics are revealed using these datasets. Nevertheless, the quantitative characteristics of the spatial and temporal distributions of these exchanges remain obscure. The exchanges are strongly controlled by environmental conditions, such as radiation, temperature, humidity, wind speed, and soil moisture. Which factors control the spatial distribution and which factors limit the temporal distribution? This study investigated the spatial and temporal distributions of water and energy exchanges using datasets obtained in North America, Europe, Eastern Eurasia, and Japan.

Materials and Method

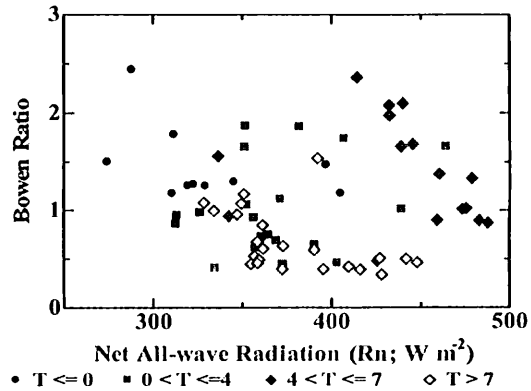
The data analyzed in this study come from nine AmeriFlux, sites, ten EuroFlux sites, and eight sites in Eastern Eurasia and Japan. They are located from 33°N to 64°N and from 142°E to 122°W. In addition to the dataset for the turbulent fluxes and meteorological elements, soil moisture content (SWC) was also used. Data that were more than two standard deviations outside the relationship between TF and net all-wave radiation were excluded from the following analysis. The period analyzed is 90 days of growing season, *i.e.*, day of year (DOY)=151 – 240, at each site, in every year. The characteristics in the 73 growing seasons are totally analyzed in this study.

Results and Discussion

Figure 1 shows the relationships between the Bowen ratio (BR) and SWC and net all-wave radiation (Rn). The BR dropped rapidly as the SWC increased from 0 to 20% and then remained constant at an SWC above 20% (see the upper figure) regardless of forest type or tree species. The lower the annual mean temperature obtained from the IIASA global climate dataset is, the larger the values of the BR for wet SWC exceeding 20%. There was no significant relationship between BR and Rn (see the bottom figure). By contrast, the opposite was true on a half-hourly basis. The BR increased with the Rn, while there was no clear relationship versus SWC at each site. These results show that spatial and long-term temporal, *i.e.*, year to year, variation in the characteristics of water and energy exchanges is strongly limited by the SWC, whereas short-term temporal distributions are controlled mainly by radiation conditions.



(a) Relationship between BR and SWC



(b) Relationships between BR and Rn

Figure 1. The spatial distributions of the water and energy exchanges above 27 forests between 33–64° N in the Northern Hemisphere

O15

SEASONAL VARIATION OF NET ECOSYSTEM PRODUCTIVITY IN JAPANESE TEMPERATE FORESTS

Y.Ohtani [1], N. Saigusa [2], R. Hirata [3], R. Ide [3], Y. Fujinuma [3], T. Hirano [4], K. Kitamura [5], Y. Kominami [6], Y. Kosugi [7], T. Miyama [6], Y. Mizoguchi [1], T. Morisawa [8], Y. Nakai [1], T. Saito [8], T. Shimizu [9], K. Tamai [9], M. Tani [7], T. Watanabe [1], Y. Yasuda [8], T. Oikawa [10] and S. Yamamoto [11]

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Micrometeorological observations of the net ecosystem productivity (NEP) were conducted in different types of temperate forests, such as deciduous broadleaf, deciduous coniferous, evergreen coniferous and mixed forests, distributed in Japanese main islands from Hokkaido to Kyushu. The measured NEP modified by data selection and empirical gap-filling procedures, obtained from 2000 to 2003, were used in this report.

The maximum NEP was largest in deciduous coniferous forest, followed by deciduous broadleaf forests. These groups had remarkably higher maximum NEP than evergreen coniferous forests, with large inter-annual variability in the growing season. In evergreen coniferous forests, the NEP's intetr-annual variability was appreciable throughout the year, but its magnitude was smaller than that of the deciduous forests. The period of positive NEP lasted for 140 to 200 days in deciduous broadleaf forests, and more than 290 days in evergreen coniferous forests. These varieties in NEP might be caused by the different forest response to the regional and inter-annual climatic variations. The response of the NEP, as the difference between gross primary productivity and ecosystem respiration, to the climatic variations will be discussed in the presentation.

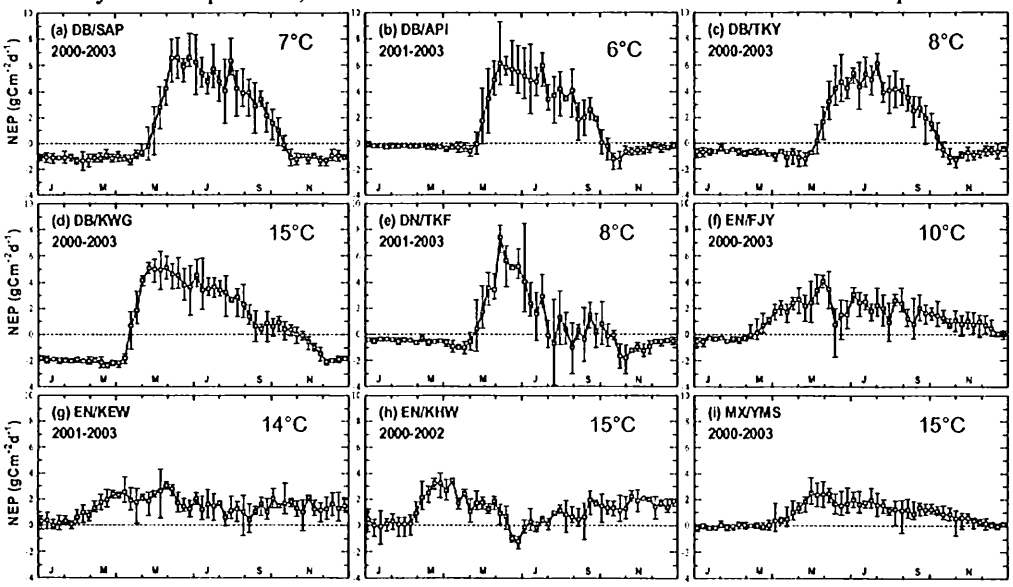

Fig. 1 Seasonal changes of NEP observed in [DB] deciduous broadleaf forests in (a) Sapporo, (b) Appi, (c) Takayama and (d) Kawagoe; [DN] deciduous coniferous forest in (e) Tomakomai; [EN] evergreen coniferous forests in (f) Fujiyoshida, (g) Kiryu and (h) Kahoku; and [MX] mixed forest in (i) Yamashiro. Square symbol tied with solid line shows weekly mean NEP ($gCm^{-2}d^{-1}$) averaged over the observation period, and the annual mean air temperature is also indicated in each panel. Vertical bar shows the maximum and the minimum NEP in weekly mean NEP among the years.

Acknowledgements: *The authors would like to thank all the project investigators, their co-workers and students for providing data. This study was supported by the following grants: 1) the Japan Ministry of the Environment (Integrated study for the terrestrial carbon management of Asia in the 21st Century on the basis of scientific advancements), and 2) the Forestry and Forest Products Research Institute (#199903, #200303: Long-Term CO_2 Flux Observation Project).*

S11

THE CARBON DYNAMICS OF TROPICAL RAIN FORESTS: LESSONS FROM FLUX STUDIES AND BIOMETRIC MEASUREMENTS IN AMAZONIA

Y. Malhi
Oxford University Centre for the Environment

In this talk I review the progress that as been made in our understanding of the carbon and water dynamics of tropical rain forests, through the application of eddy covariance and biometric techniques in Amazonian forests.

Eddy covariance studies have been able to quantify the seasonal and interannual variability of carbon fluxes in Amazonian forests. They have demonstrated that rainforests can demonstrate seasonal variability, but the pattern of this variability can vary from site to site. In forests where the water supply can be maintained in the dry season, there is often an increase of carbon uptake in the dry season as photosynthesis increases but soil respiration declines. In forests where the dry season is more severe, carbon uptake declines in the dry season. Many rainforests demonstrate seasonal phenology, but there is increasing evidence that these seasonal shifts are not triggered directly by water supplies but by internal rhythms in the ecosystem.

The issue of determining the net carbon balance of tropical forests using flux techniques has proved more challenging. The problem centres around the accurate determination of night-time CO_2 fluxes. This problem is particularly acute in many tropical forest regions because (i) night-time wind speeds can be particularly low; (ii) the tall dense canopies discourage within-canopy turbulence; (iii) the photosynthetic and respiratory fluxes are so large that small errors in respiration can lead to large errors in the net carbon balance. At some sites the application of a friction velocity filter appears to remedy this issue; at other sites the friction velocity filter is not adequate.

Flux measurements are much more valuable when couples with biometric measurements, of woody growth, litterfall, root dynamics etc. They also help to place the study site in regional context. In Amazonia, the RAINFOR network of biometric measurements has demonstrated that (i) there is large regional variability in forest carbon dynamics that is not adequately captured by the flux tower network; (ii) the regional patterns seem more driven by soil properties than by climate; (iii) there appears to be a net increase of biomass in Amazonian forests over time; (iv) tropical forests may lose up to 70% of their acquired carbon through plant respiration. I explore the consequences of these findings for how tropical forests may be responding to global atmospheric change.

S12

LAND-ATMOSPHERE INTERACTION IN CLIMATE MODEL: INDOCHINA DEFORESTATION, GLACE, AND WHAT'S NEXT

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This presentation describes some previous studies on land-atmosphere interaction with the utilization of numerical climate models, and discusses on potential future studies that may be interesting. Firstly, a numerical simulation study on the impact of deforestation on precipitation-decrease over Thailand is introduced based on Kanae et al. (2001) in *J. Hydrometeorology*. Next, results of GLACE, a model inter-comparison study under GEWEX for land-atmosphere coupling, are briefly described. Finally, we will try to discuss on future issues.

The extent of deforested area in Thailand and Indochina is large, as you might already know, after the deforestation through past decades. The evaluation of the impact of deforestation on hydrology and climate is a topic of general concern in this region. On the other hand, although most of previous numerical simulation studies (mostly for Amazon) showed decreases in precipitation occur as a result of deforestation, they did not show observational evidence. Thus, both from the viewpoint of social concern and scientific concern, the impact of deforestation on precipitation-change was an important target. In our study, statistical analyses were applied to precipitation data through 1951-1994 for each month at each meteorological station in Thailand. Significant decreases in precipitation over Thailand were detected only in the time series of monthly precipitation in September. Then, numerical experiments with a regional climate model with a simple land surface scheme were carried out for the Indochina Peninsula. In these experiments, the type of vegetation in the northeastern part of Thailand was specified as either short vegetation (the current vegetation type) or forest (the former vegetation type). The experiments were carried out using the conditions of August and September. As a consequence of these numerical experiments, a decrease in precipitation over the deforested area was obtained for September, but not for August. The climatic mechanism was speculated as follows. Precipitation in the wet season over the Indochina Peninsula basically occurs under the influence of the Southeast Asian summer monsoon system. The strong summer monsoon westerlies bring abundant moisture to the Indochina Peninsula as a source of precipitation. The monsoon westerlies are the predominant external force influencing the regional climate. However, the strong westerlies over the Indochina Peninsula disappear in September, although it is typically the month of maximum precipitation. Accordingly, it is inferred that the impact of local deforestation appears significantly only in September because of the absence of this strong external force. A simulation study with stable isotope of water also showed a positive result (Yoshimura et al., 2004, *J. Meteor. Soc. Japan*).

Although both observational evidence and numerical simulation qualitatively showed the impact of land-surface change on precipitation for the case of Thailand, a better representation of the land-impact in climate model is preferable. So, we join GLACE. GLACE (Global Land-Atmosphere Coupling Experiment) is a multi-model inter-comparison experiment focusing on the ability of land surface state to affect rainfall generation and other atmospheric processes. The experiment aims to quantify the strength of land-atmosphere coupling in the different global atmospheric models used for weather and climate studies. The hope was that the development of a "table" of coupling strengths would aid in the interpretation of the many land-atmosphere interaction studies now appearing in the literature. The representative result already appeared on Koster et al. (2004) in *Science*. The main result showed that the land-atmosphere coupling is strong enough only over semi-arid regions of the world. Although the result of GLACE is excellent as a state-of-the art modeling study, the result is not so positive in order to quantify the impact of land-surface change/variability over Asia. In addition, the inter-model difference in the degree of land-atmosphere coupling indicates difficulty in quantifying the impact of land change by using a climate model.

Finally, based on the experiences above, we want to discuss future ways to go. In terms of land-surface modeling, the utilization of stable isotope is a big challenge. We want to introduce some recent results. More investigation on modeling of boundary layer should be a big challenge as well, but we are not familiar. From atmospheric modeling point of view, modeling with very fine resolution – cloud resolving model – should be a big challenge for land-atmosphere coupling studies.

S13

CO_2 AND WATER VAPOUR FLUXES MEASUREMENT OVER A STEEP SLOPE FOREST USING TWO FLUX TOWERS

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Fluxes of CO2, H2O, and sensible heat have been measured by eddy covariance technique at carefully selected sites with flat terrain, homogeneous surface. Fluxes measurement over patchy forest at steep slope poses difficult problems since it might violate some basic assumptions underly the theory of eddy covariance technique. Among these problems, the requirement of sufficient fetch is a primary limitation on the flux measurement in mountain area of Taiwan. The possibility of using two point measurements along the prevailing wind direction to represent the fluxes of a forest stand is tested at the Chilan flux tower site, Ilan, Taiwan. The experimental site is located at a 310 ha partially managed natural regenerated conifer forest (*Chamaecyparis obtusa* var. *formosana*) and the average tree height is about 9.8 m. The stand extends down slope of a relatively uniform mountain slope with a slope of 14° facing southeast direction. Pronounced diurnal mountain-valley wind pattern was observed year round. Accompany with the valley wind, uplifted moist air brings heavy fog at the study site. With steeper slope and heterogeneous forest canopy sounded the study stand, source areas of flux measurements sometimes fall outside of the closed and relatively uniform forest stand. Based on preliminary footprint analysis, two flux towers (23.4 m and 28.6 m tall, respectively) separated by a distance of 220 meters mere established. Open path CO_2/H_2O-analyzers (LI-COR 7500 and OP-2 ADC) and 3D sonic anemometers (Young 81000 and Gill R3) were mounted on top of both towers and signals were recorded with sampling rates ranged from 10 to 20 Hz. 30-minute averaged fluxes were then calculated.

Footprint analysis showed that the source areas of flux measured at the upper slope tower were well situated within the homogeneous stand when the upslope valley dominated. As the wind shifted from upslope wind to the downslope mountain wind, source areas also shifted direction but most of them fell outside of the homogeneous stand. With an additional tower located downslope, fluxes represented the forest stand can then be estimated confidently in terms of the fetch requirement. However, as the downslope mountain wind also bring in strong sinking advection air, turbulence is suppressed as indicated by the low friction velocity, u* and downward momentum fluxes, questions on the eddy flux estimation remained unsolved especially during the nighttimes. In addition to the above-mentioned problems, Daily foggy hours estimated with a visibility meter ranges from 4.7 hours in summer to 11 hours in winter. Heavy fog occurrence at the study site causes instrument malfunction for both the open path CO2/H2O-analyzer and the sonic anemometers and thus introduces many data gaps in our fluxes estimation. However, as the cloud mountain forest consists of a large portion of forest in Taiwan, flux measurement at such a non-ideal hilly site is important and poses a challenge task for forest micrometeorological research in Taiwan.

S14

MEASUREMENTS OF CO_2 FLUXES IN A TROPICAL CITY (SINGAPORE)

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Although small in terms of land area, the urban environment is estimated to be the source from which up to 85 % of the anthropogenic emission of CO_2 originates. Urban areas are therefore significant sources for CO_2 and the influence of these emissions reaches hundreds, and for large cities even thousands of kilometers downstream the border of the source itself. However, direct measurements of urban CO_2 budges are not that extensive and have mainly been conducted in mid-latitude cities. To the authors knowledge only one such study has been reported from a tropical city (Mexico). Hence, in the context of urban development in the tropics being among the fastest growing in world, there is an increasing interest to investigate the CO_2 budgets for these environments.

Here we will present results from ongoing research in Singapore which aims to quantify urban CO_2 concentrations and fluxes as well as the urban energy balance in a long-term perspective (at least one year). The measurement site is located east of central Singapore in a residential area characterized by 10 m high buildings (Fig 1). The measurement equipment consists of a CSAT3 sonic anemometer, a Licor 7500 open path vapor and CO_2 analyzer and a CNR1 radiation sensor. The sensors have been mounted onto a tower (Fig 2) and the data are sampled at 10Hz. For the flux measurements to represent the area average characteristics of its heterogeneous surroundings the equipment has to be sited at such height that the contributions from the individual surface patches cannot be distinguished. As a rule-of-thumb this height starts at about two times the mean building height. The sensors have therefore been mounted at 20 m which should be above this co-called blending height.

The presentation will give a preliminary estimate of this city as a source (or sink) of CO_2 in general and examine the diurnal and seasonal flux patterns. In addition we will try to associate CO_2 flux variations to various emission sources, in particular those from transport.

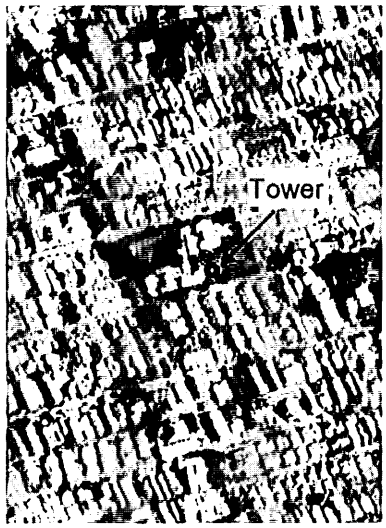

Fig 1. Aerial photo of tower surroundings

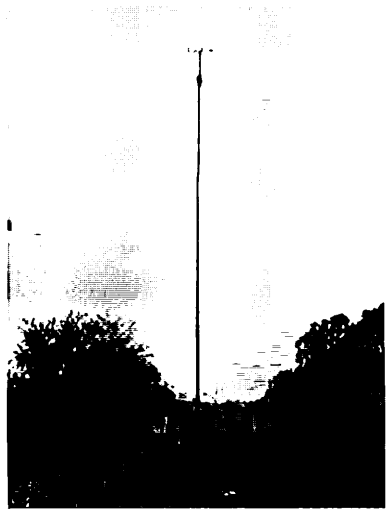

Fig 2. Measurement tower

S15

TOWARD FOUR DECADES OF FLUX OBSERVATION IN THAILAND

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Starting in 1968, preliminary of energy flux observation to study evapotranspiration of Dry Evergreen forest at Sakaerat Experiment Station (SER) in Nakorn Ratchasima province, Northeast Thailand was initiated and inconsistently observed for gases and energy fluxes until the present. Almost 20 years later, the aforementioned fluxes observation have been investigated at the Mae Klong Watershed Research Station in Mixed Deciduous forest (in 1996), and at Kog-Ma Watershed Experiment Station, Chaing Mai province in Hill Evergreen forest (in 1997- to present). Besides these 3 observation stations, energy flux has been observed in teak Plantation in Lampang province, rain-fed paddy field in Sukhothai province and cassava field in Nakorn Ratchasima under cooperatively work of TUAT and KUFF. Recently, the energy and carbon fluxes have been comparatively studied in the rubber plantation in Chachoengsao province by KU, UMR Ecologies Microbience des Sols (CNRS-University Lyon) and Department of Agriculture and Cooperatives. The soil CO_2 emission in different forest and agricultural soils and CH_4 flux from rice field have also been investigated continuously during the past decade by KMUT.

In the coming year, ThaiFlux in forms of research, development and technology transfer would be established and more publication could be contributed to those who are interested and all stakeholders related to this field.

S16

THE POTENCY OF INDONESIAN BIOSPHERE RESERVES IN ABSORBING CO_2

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Indonesia has six biosphere reserves (BR), they are: **Gunung Leuser** (in Sumatera with core zone 792,675 ha, 0-3466 m.a.s.l., major ecosystem tropical rainforest)), **Siberut Island** (in Sumatera with core zone 46,533 ha, 0-384 m.a.s.l., major ecosystem lowland dipterocarp rain forest), **Cibodas** (in Jawa with core zone 15,196 ha, 700-3015 m.a.s.l., major ecosystem mountainous rain forests); **Tanjung Puting** (in Kalimantan with core zone 415,040 ha, 0-10 m.a.s.l., major ecosystem tropical humid forest), **Lore Lindu** (in Sulawesi with core zone 217,982 ha, 200-2,610, major ecosystem montane forest;) and Komodo Island (in Flores with core zone 31,258 ha, 0-735 m.a.s.l., major ecosystem mangrove and lowland forest. Each biosphere reserve is designed to fulfill three functions: Conservation, Sustainable development, and logistic (to provide support for research, monitoring, education, and information exchange related to local, regional, national and global issues of conservation and sustainable development).

Besides the above functions there is a growing needs for the 'global wellbeing' in keeping the core area of the biosphere reserves as an important stock and sink of carbon. Therefore, we need estimation of how much carbon absorbed and stays in these forests and how to easily monitoring it.

NPP (Net Primary Production) is one of the most important variable characterizing the performance of an ecosystem. It is the difference between the total carbon uptake from the air through photosynthesis (Gross photosynthesis, GPP) and the carbon loss due to respiration (growth and maintenance) by living plants. By combining remote sensing and GIS technology with simple modeling, we can estimate GPP and NPP of a large ecosystem easier.

This paper presents the estimation of CO_2 absorption by six biosphere reserves in Indonesia through the estimation of NPP values using radiation use efficiency and estimated absorbed PAR (Photosynthetically Active Radiation). Absorbed PAR is derived from LANDSAT TM imagery. It is found that these areas are quite a significant carbon sink.

Keywords: Carbon absorption, Biosphere Reserves, Indonesia

S17

CARBON DIOXIDE EXCHANGE AT DOUBLE CROPPING RICE PADDY FIELD IN BANGLADESH

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Rice is a major crop in Bangladesh. It is practiced at least twice in the same land in a year (rice-fallow-rice pattern) and hence, it is thought that rice field plays an important role in annual carbon budget in agricultural ecosystem in Bangladesh. We have been conducting a long-term observation of carbon dioxide (CO_2) flux using the eddy covariance technique since February 2006 in Bangladesh low land rice-fallow-rice ecosystem to investigate seasonal variation of net ecosystem CO_2 exchange (NEE) between rice paddy and the atmosphere and to estimate annual carbon budget of the ecosystem. Some other related parameters were also observed. The observation site was located in the extensive farmland (24.75°N, 90.5°E, 18 m above sea level) of Bangladesh Agricultural University. A part of the farmland is occasionally used for green manuring crop in summer season. The mean annual rainfall is 2,175 mm, with 70% falling from May to August. A sonic anemometer (HS, Gill) and an open-path infrared gas analyzer (LI-7500, LI-COR) have been installed at the top of a 3-m high observation mast. Output signals from the eddy covariance sensors were sampled at 10 Hz using a data logger (CR1000, Campbell) and recorded. Half-hourly variances and covariances were calculated on line to detect instrumental failure as early as possible. The 10 Hz data were post-processed to calculate half-hourly fluxes of momentum, sensible heat, latent heat and CO_2, and also used for quality control tests. The storage term in NEE was estimated from the mean CO_2 density measured at the flux measurement height. Missing half-hourly fluxes caused by failure in power supply or those rejected by the quality control tests were filled with fluxes estimated by a parametric method (non-linear regression) from air temperature and incident photosynthetically active radiation flux density.

During the dry season of 2006 (from DOY 30 to 140), daily NEE showed a seasonal variation with a maximum net uptake rate of 9 g C m^{-2} d^{-1} at the maximum growth stage of rice (60 days after transplanting with a LAI of about 5), while the net uptake was small in early and late growth stage due to decreased photosynthetic fixation. The rice field turned a net source of CO_2 for several days immediately after the harvesting, but afterwards, it acted again as a net sink of CO_2 due to new plant sprouting (ratoon/re-growth) from the base of harvested plants and with appearance of different kinds of weedy plant. The ratio of gross primary production (GPP) to ecosystem respiration (RE) was 1.8 for the rice growing period (from DOY 34 to 140) and 1.1 for the former half of the fallow period (from DOY 141 to 185). Continuously watered conditions after the harvest with only a few drained days (from DOY 203 to 205 and DOY 212 to DOY 218) resulted in reduced soil respiration under high temperature conditions, and thereby affecting NEE in the fallow period. The observed CO_2 exchange in the fallow period differs from results in previous studies that were conducted in single cropping rice paddy fields in north-east Asia, where fields are drained during the fallow period. The difference in field management and resultant difference in CO_2 exchange in the fallow period as well as difference in cropping pattern have probable influence on the annual carbon exchange in paddy ecosystem.

S18

IN PURSUIT TOWARDS ESTABLISHING A CO_2 FLUX MONITORING STATION IN THE PHILIPPINES

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The Kyoto Protocol in the Philippines was enforced in February 2005. With it came an urgent need to evaluate the carbon sequestration in forest ecosystems. In view of the participation of the Philippine Government to this international agreement, there is a need to assess the gas exchange capacity of its major forests. Especially, since that the Philippines is an archipelagic country (*surrounded by Pacific Ocean on the east, the South China Sea on the west and north, and the Celebes Sea on the south*) with a tropical climate; is likely to be highly vulnerable to long-term climate change.

But unlike most of the countries worldwide, the Philippines is still behind in terms of CO_2 flux measurement efforts. It is sad to note that until now, the Philippines is still using the conventional way of measuring CO_2 done at the expense of cutting down trees by way of destructive sampling.

It is on this premise that we would like to embark on establishing our own flux tower station. This will be situated at the Mt. Makiling Forest Reserve in Los Baños, Laguna managed by the University of the Philippines at Los Baños.. It is a 4,244-hectare natural and secondary forest vegetated with mostly dipterocarp species. It has a rugged topography, reach up to 1,100 m asl. It has two pronounced season: wet and dry. The average annual rainfall is 2,397mm and mean annual temperature ranges from 25.5°C to 27.5°C. Ecologically, it is an important watershed area, a wildlife sanctuary, a genepool for genetic diversity, a recreational site and an educational and scientific laboratory for instruction and research. The Philippines is often struck by typhoon, and Mt. Makiling sits across the typhoon belt making it a very challenging task for the researchers to tackle. Not to mention the frequent occurrence of El Niño phenomenon that adds pressure to this forest. The influences of these disturbances on the carbon cycle can be of interest to research.

Nevertheless, with this proposed tower, we will try to monitor long-term CO_2 and energy balance (flux) between forest ecosystems and the atmosphere in order to determine whether the country is a major 'source' or 'sink' of carbon; investigate the biological responses of vegetation to the changing climatic condition; examine the effects of extreme cases like typhoon and ENSO event to the seasonal and diurnal fluxes; investigate the functions of soil ecosystems; and examine the influence of anthropogenic disturbances to the amount of emissions in a given ecosystem. The database that we will get from the flux tower can be used as baseline information to validate other researches in climate change (e.g. modeling, etc.)

But due to economic crisis, financially, we are seeking funding institutions to help us build the tower. With that, we would like to collaborate highly developed countries like Japan through the support of Asiaflux Network.

There are so many factors that ensure the success of this endeavor. Given all the endless possibilities of the uses of this flux tower...with the Philippine government to joining hands with other countries in combating global climate change...; with the people having the will to keep up-to-date with the latest technologies in atmospheric gas monitoring...; the presence of a trained researcher on CO_2 flux measurements; and the strong support from experienced local and foreign collaborators..., we are positive it will not take long before, we will be installing the most-awaited state-of-the-art CO_2 flux tower in the Pearl of the Orient Seas – the Philippines.

O21

NOCTURAL CARBON EFFLUX: RECONCILIATION OF EDDY COVARIANCE AND CHAMBER MEASUREMENTS USING AN ALTERNATIVE TO THE U*-THRESHOLD FILTERING TECHNIQUE

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Eddy covariance measurements often underestimate net ecosystem CO_2 exchange under stable atmospheric conditions at night when compared to biological measurements of plant and soil respiration. One hypothesis is that errors arise because eddy covariance instruments placed above the canopy cannot measure the horizontal flux divergences associated with lateral drainage of stably stratified air in the layer below the instruments. Measuring horizontal flux divergences is difficult because the flow of stably stratified air close to the ground is determined by the topography and the degree of stability, and measurements must thus be made in three dimensions. We present details of a novel mass-balance approach to measure the mass balance of a 50 x 50 x 6 m control volume installed in a tall *Eucalyptus* forest in south east Australia. Net fluxes of carbon dioxide from the soil and vegetation are estimated from the vector sums of fluxes through the side walls and upper surface of the control volume. The novelty of the measurement system arises from the use of windspeed-weighted sampling of air from six air lines per side wall combined with eddy flux instrumentation at 6 m.

The mass balance for a square with sides of length L and area $A = L^2$ is:

$$\begin{aligned}\overline{F_0} = {} & \frac{1}{hL^2}\int_0^L\int_0^L\int_0^h \overline{c_d}\,\frac{\partial \overline{\chi_c}}{\partial t}\,dxdydz \\ & + \frac{1}{L^2}\int_0^L\int_0^L\int_0^h \left[\overline{uc_d}\,\frac{\partial \overline{\chi_c}}{\partial x} + \overline{vc_d}\,\frac{\partial \overline{\chi_c}}{\partial y} + \overline{wc_d}\,\frac{\partial \overline{\chi_c}}{\partial z}\right] dxdydz\,, \qquad (1) \\ & + \frac{1}{L^2}\int_0^L\int_0^L\int_0^h \left[\frac{\partial \overline{c_d}\,\overline{u'\chi_c'}}{\partial x} + \frac{\partial \overline{c_d}\,\overline{v'\chi_c'}}{\partial y} + \frac{\partial \overline{c_d}\,\overline{w'\chi_c'}}{\partial z}\right] dxdydz\end{aligned}$$

where u, v, w are the wind vector components in the orthogonal x, y, z directions, t is time, c_d is the concentration of dry air, χ_c is the mixing ratio of the trace gas relative to dry air, and the overbar represents a time-average. Standard Reynold's notation is used to express the instantaneous value of a quantity as the sum of the mean and fluctuations about the mean. The term $\overline{F_0}$ represents the time and space average flux density of the trace gas at the lower boundary of the control volume. If we assume that the profiles of u and v have a constant shape and that the wind direction is constant across the control volume during a given averaging period, then the windspeed at any height can be written as

$$u(z) = u_h S(z),\; v(z) = v_h S(z)\,, \qquad (2)$$

With the further assumption that terms such as $\overline{uc_d}$ can be approximated by $\overline{u}\,\overline{c_d}$, Equation (1) can be written as

$$
\begin{aligned}
\overline{F_0} = & \frac{\overline{c_d}}{\Delta t}\left[\int_0^h \chi_c dz\Big|_{t=\Delta t} - \int_0^h \chi_c dz\Big|_{t=0}\right] \\
& + \frac{\overline{c_d}\,\overline{u_h}}{L}\left[\int_0^h S(z)\overline{\chi_c}(z)dz\Big|_{x=L} - \int_0^h S(z)\overline{\chi_c}(z)dz\Big|_{x=0}\right] \\
& + \frac{\overline{c_d}\,\overline{v_h}}{L}\left[\int_0^h S(z)\overline{\chi_c}(z)dz\Big|_{y=L} - \int_0^h S(z)\overline{\chi_c}(z)dz\Big|_{y=0}\right] \\
& + \overline{c_d}\left[\overline{w'\chi_c'} + \int_0^h \left(\overline{w}\frac{\partial \overline{\chi_c}}{\partial z}\right)dz\right]
\end{aligned}
\qquad (3)
$$

Note that $S(z)$ can be considered a weighting factor for the concentration at each height. The paper discusses in detail how the shape factor is used to calculate the vertical velocity and advection terms paper using the continuity equation for total mass flow for the control volume. Details of a practical implementation of Equation (3) scheme will be presented, along with results of a two-week field campaign in March 2005 which compares the mass-balance measurements for CO_2 with independent estimates of respiration from the soil and understorey. The relative importance of the eddy flux, change in storage, horizontal advection and vertical advection terms in the mass balance equation will be shown.

O22

FLUX-TRANSPORTING EDDIES REVEALED BY LARGE EDDY SIMULATIONS

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Most of tower flux measurements are made essentially in the roughness sublayer, which is strongly affected by coherent large-scale eddies developed near the top of plant canopy. The existence of coherent eddies causes some practical difficulties in measuring or modeling fluxes transported to/from canopies. The Monin-Obukhov similarity (MOS) does not predict the enhancement of turbulent transfer across the roughness sublayer, which leads to underestimation of fluxes when they are measured or modeled using the flux-profile relationship. Nevertheless, because of their spatial scale much larger than the canopy depth, the presence of coherent eddies more or less ensures the similarity between scalar quantities irrespective of difference in source/sink distributions. We can expect well-behaved similarity between scalar quantities when the above-mentioned coherent eddies are the dominant agent in the flux transportation. In such situations, we can use the Bowen-ratio method for measuring the heat and water vapor fluxes, while the profile shape itself is different from the MOS prediction.

The eddy covariance method is a technique to count all contributions of individual coherent-eddies that passed through a flux tower. Indeed, the signature of their passage can be recognized as the so-called "ramp patterns" in measured time traces of scalar densities. By taking averages over a long period of time, we can obtain in principle a reasonable estimate of the actual flux by this method. In reality, however, we have been facing problems of the lack of energy balance closure and the dissimilarity between temperature and water vapor fluctuations especially in low-frequency components. From the above discussions, it is clear that these problems do not arise when the coherent eddies are dominant in the turbulence spectrum. Since these problems were observed even at the most homogeneous sites, advection due to the surface heterogeneity is not the only reason. There must be a common mechanism that causes additional flux or fluctuations, independent of the surface condition.

In this study, several runs of small-scale and large-scale large eddy simulations (LES) were conducted. The small-scale LES was used to investigate the 3D structure of coherent eddies in the roughness sublayer over a homogeneous plant canopy. The revealed structure was a combination of streamwise elongated regions of high-speed and low-speed streamwise velocities, co-located with a downdraft and an updraft, respectively. The length scale of each elongated region was on average 3 to 4 times the canopy height. These properties are consistent with previous field observations showing that the sweep and ejection motions are dominant in the flux transportation across the canopy-top and that the peak wavelength of the streamwise-velocity spectrum is about 7 times the canopy height. Since this type of eddies are normally the most dominant carrier and are sampled quite well during the averaging period of eddy-covariance measurements, a large part of the actual fluxes can be captured. A problem, however, may arise if long-term (large-scale) transportation mechanisms exit in the background of these active eddies.

The large-scale LES was then applied to model the turbulent transfer in the entire boundary layer under the convective conditions, when most of the problematic cases have been observed. Simulated scalar transport in this spatial scale was not similar. The spatial perturbation of temperature (active scalar) was well correlated with the vertical motions and organized in the form of convection cells. However, the correlation between water vapor (passive scalar) and the vertical velocity was less obvious near the surface, and the spatial scale of water vapor perturbations was much larger than temperature. These differences are caused by different contributions of the entrainment to the vertical transfer of each scalar quantity. The entrained dry air, which are transferred downward by large-scale eddies, contaminates the spatial distribution of water vapor near the surface, thereby producing large-scale perturbations. Using these simulation results, some discussions will be presented with respect to possible explanations of the non-closed energy balance and the dissimilarity between temperature and water vapor fluctuations.

O23

APPORTIONMENT OF OBSERVED HEAT FLUXES TO HETEROGENEOUS SURFACES

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Heat flux data collected from the Baiyangdian (38°55'N, 115°58'E) field experiment were analyzed using footprint analyses. As a sensitive site in response to climate and environmental changes, Baiyangdian, the largest lake/wetland in Northern China Plain, is suffering from degradation or drying out in recent decades. Heat, vapor and energy fluxes and their balance in this area are of special concern, as well the CO2 flux in the related bio-system. However, difficulties exist in observation of turbulent fluxes over such a location characterized by highly heterogeneous landscape. Footprint method is used for interpretation of the observed results.

Data from two observation sites in September, 2005 were used. One site (Wangjiazhai) located in the central area of the Baiyangdian lake/wetland, was surrounded with highly heterogeneous surfaces. Another site (Xiongxian) is on land as a reference, with more uniform land cover. High resolution (25m) Landsat5 satellite imaginery was used to determine land cover in this area and four types of surfaces, i.e., farmland, water, wetland and village are assigned to each mesh of the model domain. An improved Eulerian analytical flux footprint model is applied to analyze the 'source area' of heat fluxes during this experiment and to select the turbulent flux data from the raw collection, i.e. a mixed landscape composed information from different surface types. Results show that, in general, the wetland and water surface contribute most to heat fluxes in Wangjiazhai site while the farm field contributes most to the Xiongxian site. Using the footprint distribution and the assessment of a major influence type for the observation data, heat fluxes were apportioned for water surface, wetland and farmland, respectively. Mean results show that heat fluxes of wetland and farmland are comparable. While heat flux from water surface is obviously lower during daytime (about 50 w m^{-2} and 100 w m^{-2} lower than their wetland or farmland counterparts, respectively for sensible and latent heat fluxes).

Keywords: flux footprint, Eulerian analytical model, heat flux, heterogeneous surface

O24

USING OPEN-PATH LASERS TO MEASURE AMMONIA EMISSIONS FROM SMALL FIELDS

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Ammonia (NH_3) is an indirect greenhouse gas. When emitted to the atmosphere, it affects the earth's radiation balance and the greenhouse effect through aerosol formation and cloud-forming processes. Agriculture is a strong source of atmospheric NH_3. The gas is generated from animal wastes and from the breakdown and volatilization of nitrogenous fertilizers and organic manures. NH_3 emissions are often responsible for low efficiencies of N fertilizers in agriculture. However, quantifying emissions is difficult. Not only is there a sampling problem because NH_3 is a sticky gas, but also, most of the standard techniques for measuring atmospheric NH_3 concentrations are indirect (involving wet chemistry), labour intensive and often require mains power. Recent years have seen the development of open-path sensors for measuring atmospheric NH_3 concentrations and new theoretical treatments of atmospheric dispersion, which, between them, make it possible to measure emissions of NH_3 from small, well-defined sources, such as a farmer's field. Here we describe the application of this technology to measuring emissions of NH_3 from a maize field after application of urea fertilizer. Line-averaged concentrations of NH_3 over paths of 50 to 100m were measured upwind and downwind of the field using an open-path laser mounted at 3.4m above the ground and the emission rate was calculated by application of a backward Lagrangian stochastic (bLs) dispersion model. Inputs to the model are the enrichment in NH_3 concentration as the wind blows over the field, the height and location of the measurement, the exact geometry of the field and its surface roughness, and atmospheric information including wind speed and direction, atmospheric stability and turbulence as measured by a 3 D sonic anemometer. The combination of open path laser and bLs model is sensitive enough to measure fluxes of less than 1 kg N ha^{-1} day^{-1}.

Fig.1. Half-hourly NH_3 emissions from a fertilized maize field at Yongji, Shanxi Province, China.

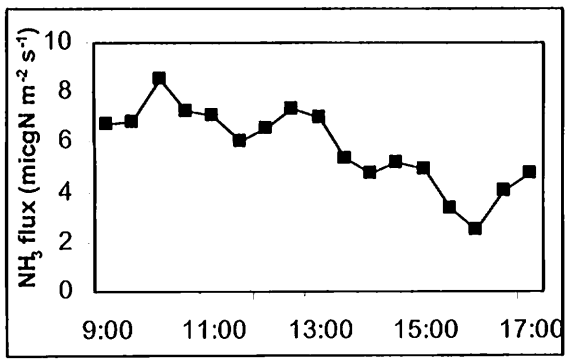

Fig.2 Aligning an NH_3 laser on its reflector. The unit is portable, battery powered, and provides continuous, instantaneous measurements. The resolution is in the ppb range.

O25

EDDY COVARIANCE MEASUREMENTS OF ISOTOPIC CO2 FLUXES WITH TUNABLE DIODE LASER SPECTROSCOPY

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Surface fluxes of CO2, 13CO2, and C18OO were measured over soybean (*Glycine mays*) for several weeks during the summer of 2006 using the eddy covariance (EC) technique. The analyzer (Model TGA100A, Campbell Scientific, Inc) uses a tunable diode laser (TDL) capable of scanning adjacent absorption lines of the three isotopomers, in the mid-infrared spectrum (~ 2300 cm^{-1}). The analyzer can be deployed in the field but requires frequent measurement of calibration gases to achieve high accuracy in the isotopic ratios. A specialized sampling system is required to obtain proper eddy covariance sampling and accurate automated measurements of the calibration gases, while minimizing the consumption of the gases. During the field study, 34 seconds out of every five minutes were used to measure three calibration gases with accurately known isotopic composition, and fluxes are computed over a 30-minute averaging period. The discussion includes description of the TDL analyzer and EC/calibration sampling system, the effects of the periodic calibration on the 30-minute flux estimate (disjoint EC), flux processing methodology, noise analysis of the measured isotopic ratios, measured fluxes and isotopic flux ratios.

026

OBSERVATION AND SIMULATION OF NET ECOSYSTEM CARBON EXCHANGE IN CHINA

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Terrestrial ecosystems play a critical role in modulating the global carbon cycle. Human activities are disrupting terrestrial ecosystems that directly affect ecosystem function. Previous studies have suggested that tropical Asia is an important source of carbon to the atmosphere, ranging from 25% to 31% of the global carbon emissions released from land since the middle of the eighteenth century. Recent estimates have indicated that tropical deforestation in South and Southeast Asia released from one third since the 1980s to more than half of the total carbon lost derived from land-use changes across the globe. However, more recent analyses based on atmospheric transport models and CO_2 observations suggested that the northern portion of monsoon Asia has acted as a carbon sink. The uncertainty in the magnitude of the carbon source or sink strength in monsoon Asia is clearly a key to balancing the global carbon budget. To reduce the uncertainty of the carbon budget in monsoon Asia and to improve our understanding of the carbon cycle at various spatial and temporal scales, the integration of multiple, complementary and independent methods used by the different research communities should be required.

This report will present the main research results related to terrestrial ecosystem carbon budget and trend in China during recent years from the following aspects: (1) Terrestrial ecosystem carbon databases, including long-term ecosystem research observation data, IGBP-terrestrial transect research data of International Geosphere - Biosphere Program (IGBP), long-term national forest inventory data (FID) and carbon flux data from eddy covariance (EC) towers. (2) Carbon budget simulation models of terrestrial ecosystems, including FID-based NPP model and process-based models. Here, we present a framework for the requisite next step in biosphere model development: a dynamic terrestrial ecosystem model coupled biological, physical and chemical processes. Especially, it includes the effects of soil carbon and nitrogen on leaf photosynthesis and an environment-based carbon allocation model. It consists of land surface processes, leaf nitrogen uptake, canopy physiology, carbon allocation, vegetation phenology, terrestrial carbon balance, and vegetation dynamics. It could simulate the dynamics of grassland ecosystem much better than IBIS model does, based on a 14-year observation of aboveground net primary productivity and 2-year flux observation by eddy covariance tower in typical steppe ecosystem in Inner Mongolia. (3) Carbon budget evaluation and prediction of Chinese terrestrial ecosystems in terms of carbon flux observation, FID data and process-based models from typical terrestrial ecosystems, vegetation types and regional level. The uncertainty of evaluating terrestrial ecosystem carbon budget and trend in China was discussed from the carbon flux observation network, long-term terrestrial ecosystem monitoring as well as model development, and some key scientific tasks related to carbon budget evaluation were suggested.

Key words: Carbon budget, Eddy flux, NECT, Transect Approach, NEE, Model

O27

COMPARISON OF ECOPHYSIOLOGICAL TECHNIQUE WITH EDDY COVARIANCE METHOD AND BIOMETRIC APPROACH FOR ESTIMATING CARBON BALANCE OF FOREST ECOSYSTEMS

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In terrestrial ecosystems, plants are the interfaces between soil and atmosphere and as well as transducers that provide the energy for microbial metabolism through the turnover of foliages and roots. On the other hand, soil CO_2 efflux is a combination of plant and microbial processes that respond to climatic drivers at a variety of temporal and spatial scales. Therefore, 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. We used automated chamber systems to continuous partitioning the net ecosystem production (NEP) among gross primary production (GPP), autotrophic respiration (foliage respiration, aboveground woody tissue respiration, and root respiration), and heterotrophic respiration at three representative tower sites – Tomakomai, Teshio and Pasoh – within the AsiaFlux. The methodology and progress will be presented. At both Tomakomai (50-year-old larch forest) and Teshio (clear-cut and reforested) sites, NEP integrated by the chamber technique matched the result observed via eddy covariance method (EC). At Tomakomai site, interannual variability in NEP was closely linked with interannual change in heterotrophic respiration, whereas at Teshio site, interannual NEP was strongly driven by the combination between regeneration of vegetation (increasing in photosynthesis) and interannual soil CO_2 efflux. At Pasoh (tropical primary rainforest) site, EC obviously overestimated NEP, probably due to EC significant underestimated ecosystem respiration (Re) under poor mixing conditions such as the calm nights. However, the corrected NEP (synthesized Re with the chamber technique) consisted with NEP that estimated by the biometric approach.

O28

THE CORRECTED METHOD OF FLUX USING GYRO AT NON-STATIC PLATFORM

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There are lots of factors needed to be overcome when measuring "accurate" flux at sea, including wave stress reduced by sea-spray, flow distortion cause of the movable ship, and other marine environmental factors.

This study is trying to simulate mobile platform at sea which using Gyro that could measure angle vectors (pitch, roll, yaw) along three axis and installed two eddy covariance systems on experimental farm for soybean in Wu-Feng Agricultural Institute, in Central Taiwan (24° 01′ N, 120° 41′ E) as Fig 1. There are three different experimental designs to measure covariance flux of atmosphere (still *vs* shaking_still, still *vs* shaking_5rpm and still *vs* 10 rpm) between 27 December 2005 and 17 January 2006, between 18 January and 20 January 2006 and between 20 January and 24 January 2006. The mechanical shaking equipment simulates mobile platform shows as Fig 2. Furthermore, we use statistics methods of OLS, average of difference and standard deviation to compare three different correction methods of two-axis rotation correction, three-axis rotation correction and sea correction method which published by Edson (1998). The results showing that the sea correction method is the most appropriate method, secondly is two-axis rotation correction. Although three-axis rotation correction is relatively unsatisfactory, it is still better than uncorrected data. Therefore, the raw data is needed to be corrected certainly.

KeywordsGyro, eddy covariance system, coordinate rotation, mobile platform, flux correction

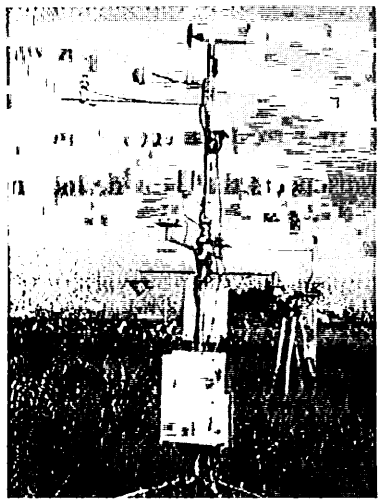

Fig 1. Two eddy covariance systems set on experimental farm.

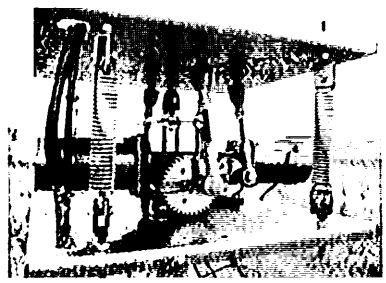

Fig 2. Mechanical shaking equipment simulates mobile platform.

O29

INTRODUCTION TO ASIAFLUX DATABASE

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AsiaFlux now stands in the entrance to the next research phase of integrative and/or inter-comparative studies. Compared with CARBOEUROPE/AmeriFlux, AsiaFlux activities are performed under diverse countries, languages and cultures. AsiaFlux will try to combine data from such activities. In this report, we introduce AsiaFlux Data Base (AsiaFlux DB), which is now constructed. Coordinated database system is sure to facilitate the multidirectional studies in flux researching communities. Development of an easy-to-use open database system, "AsiaFlux Database", is one of the key activities of AsiaFlux. An effective use of the AsiaFlux database will provide a number of benefits including:

- Distinguishing (extract) essential characteristics of material exchanges between individual sites (ecosystems) and atmosphere,
- Advances in understanding of material circulation in Asian region,
- Contribution to Asian environmental management strategy by extending cooperation with the modeling and remote sensing communities, and
- Efficient upgrading of observation techniques and analysis processes.

All data sets to be registered in AsiaFlux DB will be provided by Principal Investigators (PIs) at observation sites in AsiaFlux network. Each data should be acquired and analyzed by PIs, and contents in the data set are copyrighted to the individual PIs unless stated otherwise.

All data sets are to be downloaded by anyone at will as long as they agree and abide by AsiaFlux DB Fair-Use Policy and register as AsiaFlux DB user. We hope this DB will greatly influence this study field and encourage further education for young researchers.

We consider that the most important thing is data provider's copyright. In order to protect it and avoid their concern, we have compiled the rules for DB as fair-use policy as follows.

1) Any distribution of downloaded data to the third person for any use whatsoever is strictly prohibited.
2) If you wish to distribute the downloaded data to the third person, after post-processing and reanalyzing, you must inform the data provider and obtain his/her/their approval.
3) If your research directly conflicts to data provider's analysis, you must give clear priorities to the data provider. He/She/They may ask you to postpone the usage of the data.
4) For any publication using data from AisaFlux DB, the data provider must be informed and his/her/their approval obtained prior to publishing. The data provider may request co-authorship. A proper acknowledgement to the data provider and AsiaFlux is required.
5) All data users are required to provide reprints of paper/article using data from AisaFlux DB to data provider and AsiaFlux immediately after the publication.

The data user is required to register using Registration Form to obtain user ID and password, before any data can be downloaded.

We would like data provider to prepare document files about their data on specified format. Document files describe site information, instrument for flux/meteorological measurement, calculation method and revision number. We realized that flux data are sometimes recalculated, so we can confirm it from the document. The document files should ensure the data traceability. Document files are packed with data files.

AsiaFlux committee members wish "AsiaFlux database" becomes the entrance for new studies and produces new encounters.

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O31

EFFECT OF ORGANIC MATTER VARIATION ON DECOMPOSITION PROCESS IN FOREST ECOSYSTEM -EVALUATION USING MODIFIED ROTH-C MODEL-

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The structure and function of carbon budget in soil should be understood for the estimation of long-term forest carbon sequestration. Annual carbon accumulation in soil is considerably small, so it is much difficult to measure the accumulation rate directly and estimate as a difference between organic matter input and decomposition carbon loss. Soil organic matter (SOM) turn over models are effective at simulating temporal changes in SOM. These models have conceptual organic matter pools and can calculate flows and storages of carbon as a function of environmental factors and decay rate of each component. Numerous SOM turnover models have been developed for grassland and crop fields (e.g. Parton et al. 1987; Jenkinson, 1996). Forest litter is characterized as a great amount of wood litter, such as branch, stem, and root litter. So to evaluate carbon budget in forest soil, the model should contain their mortality and decomposition processes. Decomposition rate of wood litter is slower than that of leaf litter. Wood decomposition process is affected by chemical and physical characteristics of wood material (Harmon et al. 1986). Our objective of this study is to modify a SOM turnover model to give a better fit to carbon budget in forest soil. Primarily, we check existing and new setting parameters for leaf and wood decomposition in the model.

Materials and methods

We modified a SOM turnover model of Rothamsted Carbon Model (RothC, Coleman and Jenkinson, 1996). Roth-C model is a model of the turnover of organic carbon in non-waterlogged soils that allow for the effects of soil type, temperature, moisture content and plant cover on the turnover process. It needs few inputs and those it needs are easily obtainable. Soil organic matter is split into four active compartments and a small amount of inert organic matter. Incoming plant carbon is split between decomposable plant material (DPM) and resistant plant material (RPM) depending on the DPM/RPM ratio of incoming plant material. Shirato and Yokozawa (2006) indicated that the ratio can be obtained from an experimental measurement and reported the ratio of both leaf and wood litter. Thus, we checked primarily the validity of the ratio of wood litter. Moreover, we examined the effect of wood size that is one of the important factors affecting wood decomposition rate (e.g. Harmon et al. 1986) on wood decomposition process in the model. Investigation of model parameters was conducted by comparing between model outputs and measurement values of decay rate and CO_2 efflux of leaf and wood litter.

Results and Discussion

The DPM/RPM ratio of leaf litter is provided 0.2 for tree leaf litter in the Roth-C model. Shirato and Yokozawa (2006) reported that this value was consistent to the value obtained from experimental measurement. In our site, leaf litter decay rate simulated by the model is almost consistent to the observed value. On the other hand, DPM/RPM ratio of woody material (0.13 provided by Shirato and Yokozawa, 2006) gives a faster decay rate than the observed. Therefore, incorporation of wood decomposition process into the model needs other parameters that express the physical and chemical properties of wood materials.

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032

CARBON ACCUMULATIONS IN FOREST SOILS OF NORTHERN THAILAND AS CARBON POOLS IN THE GLOBAL ECOSYSTEMS

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Fifty-one soil pits sampled from different locations in various forest types and subtypes of northern Thailand are interpreted, synthesized and reviewed to explain about organic carbon accumulations as a carbon pool in the forest ecosystem. The forests include 5 types (1) dry dipterocarp forest (DDF), (2) mixed deciduous forest (MDF), (3) dry evergreen forest (DEF) (4) pine forest of two subtypes, pine-dry dipterocarp forest (P-DDF) and pine-lower montane forest (P-LMF), and (5) montane forest (MF) consisted of 3 subtypes; lower montane forest (LMF), middle montane forest (MMF), and upper montane forest (UMF).

Soil types in these forests are classified into 4 Orders; Entisols, Inceptisols, Ultisols and Alfisols. The Entisols represent very shallow rocky soil profiles, less than 50 cm. Order Inceptisols are developing soil profiles deeper than that of Entisols (50-100 cm), and have poor clay accumulation in subsoils. The Ultisols are well developed soils, depth of 100 cm or more, high clay accumulation in subsoils, and base saturation <35%. The Alfisols are similar to Ultisols that contain high clay contents in the profiles. These soils usually develop on limestone area with the depth of 100 cm or more, base saturation > 35%.

Soils under DDF vary from Entisols to Inceptisols and Ultisols (Suborder Ustults). Carbon storages in one-meter depth are normally varied between 12.11-93.66 t/ha. It is exceptional for a high carbon amount as 106.68 t/ha for soil in limestone area. MDF soils are usually Inceptisols and Ultisols (Suborder Ustults), and contain 94.8-197.29 t/ha of carbon. The DEF are Inceptisols or Ultisols (Suborder Humults), with carbon of 56.51-93.41 t/ha. Most soils under montane forest are Ultisols (Suborder Humults). The LMF soils are Ultisols with carbon storages of 96.72-201.66 t/ha. The MMF soils are Order Ultisolss, 173.12 t/ha of carbon. The UMF soils are Order Inceptisols or Ultisols, and contain the higher carbon accumulation, 237.49-371.04 t/ha.

Differences in soil types, forest types and conditions, parent rocks, altitude, forest fire and topographic conditions are important factors affecting amounts of carbon accumulations in forest soils of northern Thailand.

033

EXPLORING THE VARIATION OF ABOVE-GROUND WOOD PRODUCTIVITY AND ROOT PRODUCTION ACROSS 50-HA PASOH FOREST PLOTS AND THEIR RELATIONSHIP TO SOIL DETERMINING FACTORS

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The net primary productivity (NPP) of an ecosystem is the net amount of carbon that is fixed from the atmosphere into new organic matter per unit time. Understanding the relative magnitude and spatial and temporal variation of these terms is a subject of considerable interest, for testing our understanding of the functioning of ecosystems, the role of the biosphere in global biogeochemical cycles, and the response of ecosystems to local and global perturbations. However, below or above-ground NPP are still poorly quantified and their relationship to environmental factors not well understood, particularly in tropical forests and savannas. This study attempts to assess some components of forest productivity by using the censuses or forest inventory of Pasoh Forest Reserve, Peninsular Malaysia and conduct measurement on litterfall and root production to acquire more comprehensive estimates of productivity and allocation. Here we define above-ground wood productivity as the rate of carbon fixed and produced in woody biomass such as coarse stems and branches. The magnitude and variation of coarse wood productivity can be directly determined from the long term forest census data, using the approach and corrections. The assessed spatial variation of above-ground productivity and root production will be explored over the forest plot. The study aims to evaluate the questions as follow:

1. Is there a significant relationship between productivity and soil properties with the 50 ha plot?
2. What are the main soils or landscape factors contributing to the productivity variations?
3. How do the patterns observed at Pasoh compare with the productivity-soil trends observed in the Neotropics? Do Paleotropical forests fall into the same explanatory framework, or are they fundamentally different?

O34

MOISTURE AND TEMPERATURE EFFECTS ON RESPIRATION OF AGRICULTURE AND FOREST SOILS IN THAILAND

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We investigated soil respiration both in the field and laboratory incubation to understand the relationship between soil respiration, and soil temperature and moisture in tropical upland soils. Diurnal variations of *in situ* CO_2 efflux was studied in May 2004 and February 2005 at an agricultural site (maize) and a dry evergreen forest. In the laboratory, we measured soil respiration in a short-term incubation under various moisture contents (air-dry, 25, 50, 75 and 100%WHC) and various constant temperatures (10°C to 45°C). The soil CO_2 flux showed significant diurnal changes and these patterns were highly correlated with both air and soil temperatures. CO_2 efflux from both study sites increased to the maximum values during the late afternoon, usually 2-4 hours after a peak in air temperature. The total soil CO_2 effluxes integrated over one day period were 1354 and 3082 mg CO_2 m^{-2} at agricultural site and 1467 and 12851 mg CO_2 m^{-2} at forest site in May 2004 and February 2005, respectively. The Q_{10} values for agricultural site estimated from relationship between soil temperature at 5 cm and CO_2 efflux was 3.37 (available only in May 2004). For forest site, the Q_{10} was 2.04 (available only in February 2005). Results from laboratory study indicate that the topsoil layer (the top 20 cm) contributed mainly to the overall respiration. Soil respiration was highest at moisture between 20% and 75% WHC. The Q_{10} values of agricultural soil were higher than of forest soil in laboratory incubation, confirming the field measurement results. Laboratory results also indicate that subsoil was more sensitive to temperature and moisture changes than topsoil.

O35

PARTITIONING OF WATER FLUX IN RUBBER PLANTATIONS: ESTIMATION OF TREE TRANSPIRATION BY SAP FLOW MEASUREMENT

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In Thailand, rubber is the major tree crop covering more than 2 millions hectares. Its impact on environment, and particularly water use, is a major issue. In order to assess water balance of tree plantations at plot scale, it is necessary to partition total water flux measured by eddy-covariance between soil and understorey evaporation (E), tree transpiration (T). Therefore, accurate dynamic measurement of tree transpiration is required.

Sapflow was measured in a 12 years old rubber plantation (RRIM 600) in eastern Thailand, by heat dissipation method (Granier 1985, 1987) using home-made 20 mm-long radial probes, continuously heated (0.2 W), and connected to a data logger. The calibration of the home-made probes was checked in the laboratory with reference to the gravimetric method.

We adjusted the experimental devices to rubber field conditions and evaluated the different sources of variability to design the appropriate monitoring process. Natural thermal gradient was not significant. Vertical variation along the trunk below canopy was low. Conversely a significant azimuthal variation was recorded, though without specific trend. Accordingly 2 probes (one on the North face, one on the South face), located above the tapping panel were used for monitoring.

Radial distribution of sapflow was recorded, using a long probe, and our results showed significant variations of sapflow along the radius. A function was derived from these radial variations to estimate total tree sapflow from measurements within the outer 2 cm of sapwood. Finally to evaluate stand transpiration (mm h^{-1}), trees were sampled according to trunk diameter. Transpiration data will be processed together with flux data obtained from eddy-covariance.

Keywords: Sapflow, transpiration, field monitoring.

O36

STRAW MANAGEMENT AS KEY FACTOR FOR DETERMINING PRESENT AND FUTURE GREENHOUSE GAS EMISSIONS FROM RICE ECOSYSTEMS

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Wetland rice fields are a source of the greenhouse gas (GHG) CH_4 and – to a lesser extent – N_2O. CH_4 emissions are generally enhanced by organic inputs into the soil and thus, are correlated to straw recycling. The actual impact of straw amendments, however, depends on a variety of management factors. This study summarizes various field studies as well as incubation experiments conducted in the Philippines. The common practice of incorporating rice straw during field preparation resulted in seasonal averages of 30 to 250 mg CH_4 m^{-2} d^{-1}. Early residue incorporation (i.e. app. 30 d before field preparation) reduced emissions by 81 %, 18 % and 54 % in the different seasons studied. Emissions could also be reduced when the straw was either composted or mulched on the soil under zero-tillage.

However, GHG emissions triggered by straw in flooded soils have to be seen against GHG emissions from straw burning which is the prevailing practice in rice farming systems. Agricultural crop residue burning is increasingly posing local health hazards and adds significantly to global warming by emitting large amounts of N_2O. Therefore, this presentation also assesses alternative uses of rice straw with the potential to mitigate overall (i.e. on-farm and off-farm) emissions. There are several technological options to utilize rice straw for energy (and thus, offsetting CO_2 emissions from fuel) or carbon sequestration. While none of these options has yet achieved wide acceptance, they will become more attractive under high prices of fossil fuel and may gradually change the practices of straw management in the near future.

037

ASSESSMENT OF THE CARBON BALANCE IN A FORESTED WATERSHED OF TAKAYAMA BY ECOLOGICAL PROCESS-BASED APPROACH

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Is the forest ecosystem a source or a sink of carbon, and how will global climate change affect the forest carbon balance? This critical question remains difficulty to answer, in part because of spatial heterogeneity such as in mountainous region, Japan. The carbon net balance is sum of two large terms: photosynthetic carbon uptake and respiratory carbon release. The ecological process-based method provides a detailed assessment of belowground compartment as one of the major compartment of carbon balance. This method is determined by the balance between net primary production (NPP) of vegetation and heterotrophic respiration (HR) of soil. The carbon balance of forest ecosystems was estimated in Daihachigakawa watershed, Takayama, Japan since 2004. To estimate the NPP, we applied a biometric method involving tree allometric analysis and litter traps for biomass measurements. Moreover, to estimate the annual soil carbon emission (SR), we used a chamber system with automatic open and closing for measuring continuous soil CO_2 efflux based on an open-flow method, a portable system for measuring soil respiration (LI-6400) and a closed chamber method by soil air samples. Our object is to evaluate (1) the ecosystem carbon balance in second-growth deciduous forests, plantations of Japanese cedar and a larch forest at the Daihachigakawa watershed, (2) the relationships between ecosystem carbon pools and fluxes and (3) temporal changes in soil CO_2 effluxes of the above forest types. The overall goal of this study is to investigate carbon cycling on a regional scale using ecological process, remote sensing, and climatic observation and modeling analysis as a part of the COE program "Satellite Ecology". The study region refers to a cool temperate zone, Asia monsoon climate. The study area was located in Takayama city, central Japan (Fig. 1, 36° 08' N, 137° 22' E). The annual mean of air temperature and precipitation for the sites were 7.2~11°C and 1745~2079 mm, respectively. The Q50, Q20 and Q7 stands composed mainly by *Quercus* are secondary deciduous forests of 50, 20 and 7 year old, respectively. C50 and C3 sites composed by Japanese cedar (*Crytomeria japonica*) are 50 and 3 year old plantations. L50 stand composed by larch forest (*Larix kaempferi*) is 50 year old. Biomass of C50 stand was larger than other stands (C50>L50>Q50>Q20>Q7>C3). The aboveground NPP (ANPP) of Q7 stand was largest (Q7>C50>C3>Q20>Q50>L50). There were significant exponential relationship between soil CO_2 efflux and soil temperature in all stands. There was higher ANPP and SR in Q7 stand than those of other stands. We found a significant correlation between ANPP and SR (Fig. 2). The results suggest that linkage between the remote sensing method using the satellite data and ecological process- based method provides a key approach to evaluate carbon balance and dynamics in a mountainous region.

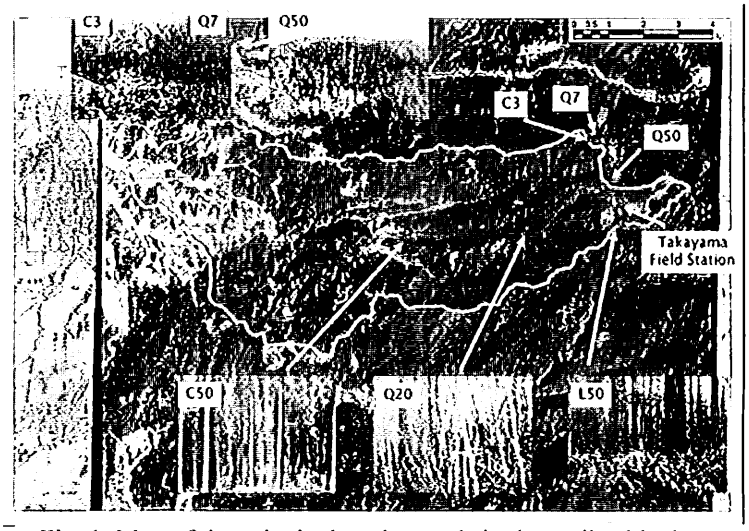

Fig. 1. Map of the principal study stands in the Daihachigakawa watershed, Takayama.

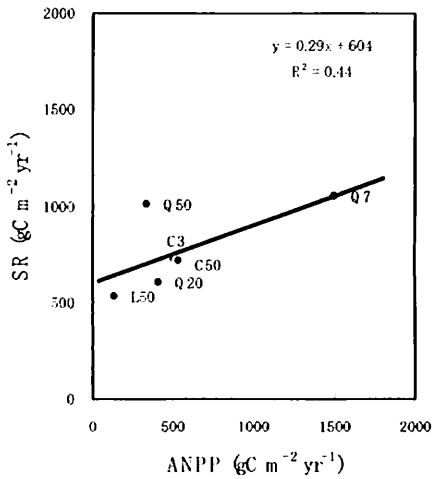

Fig. 2. Relationship between ANPP and SR for six forest stands.

041

MOVING TO THE REGIONAL-SCALE: ATMOSPHERIC BOUNDARY LAYER CONCENTRATIONS AND SURFACE FLUXES

J. Berry

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Precise measurements of the concentration of trace gases and isotopic ratios have been made for up to 50 years at a number of locations around the world. These measurements have been widely used to track changes in the total atmospheric burden of CO_2 and to estimate the geographical location of sources and sinks for carbon. Measurements of other trace gases and isotopic species have been used to infer the respective roles of the oceans, terrestrial biosphere and human activities in the carbon cycle. Adding such measurements at flux sites around the world would greatly increase the sampling of trace gases in the atmospheric boundary layer over the continents. My talk will review some technologies for making such measurements; what level of precision is needed for such measurements to be useful, and some approaches for using these measurements for model validation and to infer surface fluxes at regional scales.

042

CARBON SINKS AND SOURCES IN CHINA'S FORESTS DURING 1901-2001

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This paper reports annual carbon (C) balance of China's forests during 1901-2001 estimated using the Integrated Terrestrial Ecosystem C-budget model (InTEC). Annual carbon source and sink distributions are simulated for the same period using various spatial datasets including land cover and leaf area index obtained from remote sensing, soil texture, climate, forest age, and nitrogen deposition. During 1901-1949, China's forests were a source of 21.0±7.8 Tg C yr^{-1} due to disturbances (human activities). Its size increased to 122.3±25.3 Tg C yr^{-1} during 1950-1987 due to intensified human activities in late 1950s, early 1960s, 1970s and early 1980s. The forests became large sinks of 176.7±44.8 Tg C yr^{-1} during 1988-2001, owing to large-scale plantation and forest regrowth in previously disturbed areas as well as growth stimulation by nondisturbance factors such as climatic warming, atmospheric CO_2 fertilization, and N deposition. From 1901 to 2001, China's forests were a small carbon source by 3.32 Pg C, about 32.9±22.3 Tg C yr^{-1}. The overall C balance in biomass from InTEC generally agrees with previous results derived from forest inventories of China's forests. InTEC results also include C stock variation in soils and are therefore more comprehensive than previous results. The uncertainty in InTEC results is still large, but it can be reduced if a detailed forest age map becomes available.

Key words: Carbon sink, Carbon source, Forest, Carbon cycle, China

043

SATELLITE AND TOWER FLUX COMPARISONS OF SEASONAL VEGETATION DYNAMICS IN MONSOON ASIA

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The metabolism and phenology of the world's rainforests significantly influence global dynamics of the Earth system through their role in biogeochemical cycling and climate, and as major reservoirs of the planet's biological diversity. Despite their enormous importance, the impact of environmental and human factors on tropical forest functioning and phenology remain poorly understood. Recent neotropical rainforest studies with in-situ tower flux measurements of gross primary productivity (GPP) and regional satellite observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) have shown dry season increases in vegetation photosynthesis resulting from greater seasonal availability of sunlight. These studies yield consistent depictions of forest seasonality but contradicted ecosystem models that predict dry season declines in photosynthesis due to water limitations. Intact rainforests appear to avoid dry season water stress through root access to deep soil waters and hydraulic redistribution. However, a reversal in the seasonal patterns of ecosystem fluxes and satellite phenology was found in disturbed forests and with forest conversion. In this study we assessed the extent to which the tropical rainforests in Southeast Asia respond similarly as the neotropics to sunlight, moisture, and human controls on seasonal ecosystem functioning. Tropical forest degradation induced by land use pressures is more prominent in Monsoon Asia and deforestation rates are the highest on the planet with important consequences to tropical forest sustainability, fire susceptibility, carbon emissions, and resilience to land-use pressures.

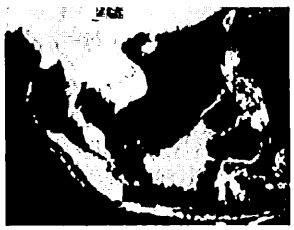

Figure 1. Southeast Asia EVI annual average

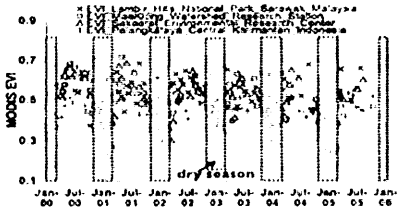

Figure 2. MODIS EVI time series of 4 sites.

We analyzed the phenology of Monsoon Asia at multiple scales with 6 years of MODIS satellite measures of 'greenness', using the Enhanced Vegetation Index (EVI, an index of canopy photosynthetic capacity). More intense analyses were conducted at local field study sites and with seasonal canopy photosynthesis measured from eddy flux towers at the MaeKlong Watershed Research Station (mixed deciduous tropical forest, 14° 34.57'N; 98° 50.62'E) and the Sakaerat Environmental Research Center (dry evergreen broadleaf tropical forest, 14°29.6'N;101°55.32'E), both in Thailand. Satellite EVI data was well correlated with seasonal and interannual tower GPP measurements at both Thailand sites.

However, satellite measured greenness and tower flux GPP measurements from these sites, at 14^0 latitude, were positively correlated with precipitation seasonality, such that photosynthesis was more tightly coupled with water availability, as found in the drier and transitional, southern Amazon rainforests.

The more moist rainforest sites, closer to the equator, such as Lambir Hills National Park in Sarawak, Malaysia (4.1865^0 N;114.017^0 E) and Palangkaraya in Central Kalimantan, Indonesia (2° 20.7' S; 114° 2.183' E) displayed satellite greenness phenologies that were less well coupled with rainfall and showed slightly higher photosynthesis in the dry season when light availability was stronger. As there were no tower flux data available over these wetter areas, our results are not entirely conclusive as to whether neotropical and Monsoon Asia tropical ecosystems respond similarly to light and rainfall controls. Throughout the region, however, land disturbances resulted in satellite phenology profiles that strongly followed precipitation seasonality.

044

COMPARISON OF SATELLITE GREENNESS DATA WITH FLUX TOWER MEASUREMENTS IN AMAZON

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Recently, a better understanding of vegetation phenological responses to environmental factors, e.g. climate is necessary to develop reliable biosphere-atmosphere and climate models for predictions of mass and energy exchanges between the land surface and atmosphere. The Amazon, the largest extent of tropical rainforest on the Earth with extensive tropical savannah (cerrado) and ecotone, is under great pressure of landuse/ landcover changes from anthropogenic impacts. For more than two decades, the Amazon region has been transformed into pasture and agricultural uses with significant consequences on biodiversity, biogeochemistry, carbon and water budgets, and productivity in regional and global scales. The controlling mechanisms and factors on tropical forest phenology and productivity are not well understood, yet the Amazon basin continues to undergo rapid rates of human-induced disturbances.

Therefore, the objectives of this study were to investigate the interactions of moisture and light controls and vegetation physiognomy on vegetation phenology across various eco-climatic transects traversing rainforest, transitional, and cerrado biome types with intact and converted forest areas. Then, we evaluated the satellite-derived greenness seasonal variations with flux tower photosynthesis data to examine the consistency of the MODIS EVI with local flux measurements.

We utilized 5-years Moderate Resolution Imaging Spectroradiometer (MODIS) Enhanced Vegetation Index (EVI, "greenness" or canopy photosynthetic activity measurement) satellite time series data to analyze seasonal and spatial patterns of biological vegetation activity over the Amazon basin. We found MODIS EVI depicted significant trends in landscape phenology observed across the rainforest, cerrado and ecotone forests with strong seasonal shifts resulting from differences in vegetation physiognomic responses to rainfall and sunlight. In the cerrado region, strong seasonality with greening and browning was tightly coupled to rainfall. The dense and open tropical rainforest phenologies were more controlled by seasonal variations in sunlight with greening in the sunnier dry season coincident with periods of maximum solar radiation. This suggested the rainforest ecosystems were light-limited. Significant changes in phenology were observed in both converted- ecotone and open rainforest with greening synchronized with rainfall and browning coinciding with the dry season, resulting in a forest conversion seasonality similar to the cerrado. In contrast, transition ecotone forest seasonal dynamics were unique and complex, as neither sunlight nor rainfall had a direct influence on the forest metabolism and phenology.

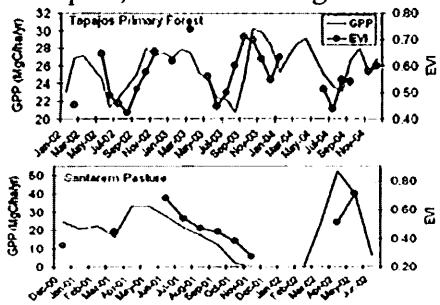

Fig. 2 Comparison between satellite-based EVI and GPP at Tapajos dense rainforest and Santarem pasture sites.

We compared the EVI seasonal profiles with the eddy flux tower measures of canopy photosynthesis or gross primary productivity (GPP). Overall, the EVI seasonal profiles at the tropical rainforests and conversion sites behaved similarly to GPP profiles confirming the MODIS EVI greenness patterns. This suggests that satellite-based greenness measures with EVI, in intact and converted rainforests can be confidently related with their photosynthetic activity.

Therefore, MODIS satellite greenness measures are potentially useful for quantitative and consistent regional estimates of carbon dynamics and for monitoring human-induced landcover changes.

045

THE SIMULATION OF WATER VAPOR AND CARBON DIOXIDE FLUXES OVER IRRIGATED FARMLAND BY MODIFIED SOIL-PALNT-ATMOSPHERE MODEL (mSPA)

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The exchange of CO_2 and water vapor in the farmland was examined with a two-layer canopy model (mSPA model). The study site is located in a southwestern end of Korean peninsular (34.55°N, 126.57°E) which is part of the Koflux sites (Haenam). The turbulent fluxes of energy and CO_2 were measured from October of 2002 to September of 2003 by eddy covariance method. The landcover was the mixture of rice paddies and various agricultural crops such as beans and sweet potatoes etc. Four cases were selected for detailed examination among southeasterly wind cases during growing seasons (June to September in 2003). The footprint area consists of mostly rice paddy field. Case 1 is characterized by low LAI, small root biomass and high vapor pressure deficit while Case 2 is characterized by near maximum LAI, large root biomass and moderate vapor pressure deficit. Cases 3 and 4 are characterized by ripening period and maturity period, respectively. The simulated diurnal variation of turbulent fluxes agrees well with observation in Cases 1 and 2. However, the model fails to simulate both latent heat flux and CO_2 flux during late growing season (Cases 3 and 4). The observed assimilation–stomata (A-g_s) relationship shows a different slope between mid-growing season and late growing season while modeled one shows same slope in both seasons.

Sensitivity test was performed to investigate the influence of uncertainties of prescribed model parameters on simulated cumulative GPP and evaporation during growing season. During this period, vapor pressure deficit was moderately low and soil moisture was ample due to irrigation and rainfall. The cumulative evaporation showed little sensitivity to both LAI and V_{cmax} due to compensating effect of soil evaporation. The cumulative GPP showed a larger sensitivity to LAI than V_{cmax} , which emphasizes the importance of good estimates of LAI for reasonable long-term GPP estimate. For hydraulic parameters such as stem hydraulic conductivity and root resistivity, model showed little sensitivity. It is due to low water stress during the growing season.

Keywords: Farmland, Net ecosystem exchange, mSPA model, Eddy covariance fluxes

046

MODELING SEASONAL VARIATION OF CO_2 FLUX IN A SUBTROPICAL CONIFERIOUS FOREST USING THE EALCO MODEL

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EALCO (Ecological Assimilation of Land and Climate Observations) model is a process-based model used to simulate the carbon, water and energy exchange between the atmosphere and land surface. It has been succeeded in modeling the deciduous ecosystem in boreal forest and contributing to the study of ecosystem processes. Seasonal drought frequently happens in the southern subtropical region of china, which was commonly combined with high temperature. Flux measurements using eddy covariance technology at Qianyanzhou site (QYZ) (26°44'N, 115°03'E, 110.8m) of ChinaFLUX have been made since October of 2002 in order to investigate the carbon flux characteristics and the impact of seasonal drought on terrestrial ecosystem processes. QYZ is located in southern China, influenced by subtropical monsoon climate. The vegetation is man-panted coniferous forest. It's a relatively dry year in 2003 (precipitation=855 mm), with 35% less precipitation than the historical average. The year 2004 has a close to normal precipitation of 1325mm. The contrasting climate conditions over these two years enables us to test the sensitivity of carbon exchanges to seasonal drought (combination of increasing temperature and declining precipitation) with EALCO model, which is one of the possible trends in the future climate projections.

In this study, EALCO model is parameterized to simulate ecosystem carbon exchange process in the man-planted evergreen forest. Simulation results have been validated using the half-hourly carbon fluxes and daily and annual GPP (gross primary production), NEP (Net ecosystem production) and TER (Total Ecosystem Respiration) estimated from eddy covariance measurements. The influences of seasonal drought on ecosystem photosynthesis and net ecosystem carbon budget have also been discussed.

In general, the model can considerably simulate the two years' carbon fluxes among soil –plant –atmosphere on hourly, daily and annually scale. Both the simulations and observations showed strong impact of drought on GPP in 2003. Compared with 2004, the annual GPP in 2003 decreased 12.9% according to observations (1610 vs. 1865 g C m^{-2}) and 11.2% according to model results (1637 vs. 1844 g C m^{-2}). The diurnal variations of NEP from both observations and simulations during the period of soil water deficit show asymmetric format, that is, the peak value of carbon exchange accrued on a certain time in the morning then decreasing with time. Modeling results indicate that water stress have more influence on TER than photosynthesis, which lead to the decrease of NEP. Further analysis suggests that deep soil water content controls the canopy photosynthesis dramatically in sunny day before noon time during soil water stress. While after noon time both high temperature and deep soil water content eliminate the GPP and their elimination percents are equal. In cloudy days, radiation and deep soil water content primarily determine the photosynthesis and temperature becomes a minor controlling factor generally.

Poster Session

P01

CARBON SEQUESTRATION IN EAST ASIA: A MINI-REVIEW OF EDDY FLUX MEASUREMENT STUDIES

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The terrestrial ecosystem and the physical climate system are strongly coupled through carbon exchange. However, major uncertainties in the magnitude of these feedbacks to climate change are still remaining. To solve these problems, many research activities has built up the eddy flux tower monitoring the carbon dioxide exchange over the canopy of natural ecosystems and attempt to clarify the carbon dynamics between the atmosphere and the terrestrial ecosystems in East Asia. Most of them have published their measured results in the international and domestic scientific journals in these years. There is, however, no summarized discussion with regard to their relationship of carbon dioxide exchanges against environmental gradients on the sub-continental spatial scale. To understand the present situation of carbon sequestration capacities over whole of East Asia and to recognize the inherent problems in terms of tower installation location and coverage rates of each ecosystem types in East Asia, the summarizing report of the already-stored data about annual carbon uptake values is to be shown as quickly as possible.

We review the published results of the eddy covariance flux measurements, which have been conducted in more than twenty field points within East Asia (70 °N – 10 °S, 90 °E – 150 °E) in these ten years (Fig. 1), and investigate the relationships between carbon dioxide budgets and environmental factors in East Asia. Annual net ecosystem exchanges (Ann. NEE) of carbon dioxide is higher in the dipterocarp forest in tropical region and lower in alpine grassland on Tibetan Plateau and larch forest in high-latitudinal region. The relationship between Ann. NEE and latitude is linear-like but not so clear (Fig. 2). Against to annual mean air temperature, Ann. NEE indicated relatively clear positive relationship without reference to ecosystem types. Ann. NEE and annual gross primary production (Ann. GPP) show a negative and strong positive correlation to maximum leaf area index and annual ecosystem respiration (Ann. Re) also increases with annual mean air temperature increasing. These indicate that annual ecosystem carbon fluxes have apparent correlation with environmental factors rather than geographical location. On the other hand, it is found that further research is needed in higher and lower latitudinal regions, in which there is smaller number of evidence.

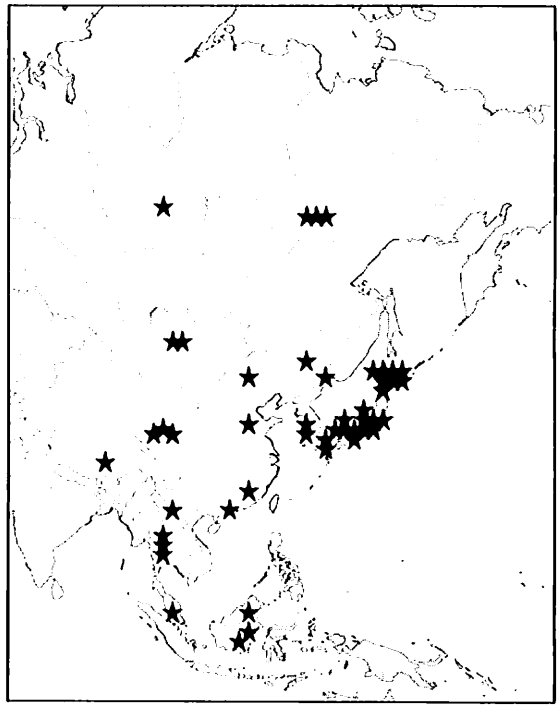

Fig. 1. Location of eddy flux measurements in East Asia.

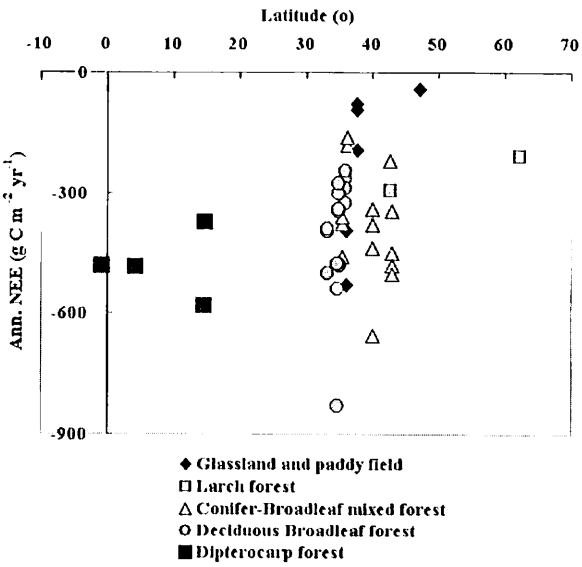

Fig. 2. Annual net ecosystem exchange along latitudinal trend.

P02

FLUX OBSERVATION AND EVAPOTRANSPIRATION OF THREE LAND USE TYPES IN THAILAND

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An intensive flux observation were carried out in various types of land use, Thailand. In order to find out the heat budget and evapotranspiration (ET) in difference types of land use, which are paddy field, teak plantation and cassava field in Sukhothai, Lampang and Nakhonratchasima Provinces. Each land use type was installed the automatic weather station (AWS) in different height of tower. The measurement of energy balance using Bowen ratio technique and collecting data between January – December 2005.

The results showed that an average daily solar radiation (R_s) of the whole year in paddy field was 19.3 MJ m^{-2} and an average daily net radiation (R_n) was 13.2 MJ m^{-2}, while in teak plantation and cassava field, the average daily R_s was 19.0 and 18.6 MJ m^{-2}, and an average daily net radiation (R_n) was 14.8 and 14.3 MJ m^{-2} respectively. The average daily ET of paddy field was 4.1 mm. while the average daily ET of teak plantation and cassava field were 3.9 and 4.7 mm. respectively.

Comparison of latent heat flux, sensible heat and soil and water heat flux among land use type found that in paddy field almost 72.3 percent of R_n was used for latent heat of vaporization (LE), while in teak plantation and cassava field were only 71.6 and 68.7 percent of R_n. On the other hand sensible heat (H) in cassava field was 27.5 percent of R_n while in paddy field and teak plantation were only 22.9 and 23 percent of R_n respectively. Heat storage in soil and water (G_s, G_w) in paddy field were 3.1 and 1.7 percent of R_n while G_s in teak plantation and cassava field were 5.4 and 3.8 percent of R_n respectively.

P03

EFFECT OF ENVIRONMENTAL FACTORS ON CARBON DIOXIDE EXCHANGE OF FOREST ECOSYSTEMS IN EAST ASIA

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[2]National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan
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[4]Hokkaido University, Sapporo, Japan
[5]Kyoto University, Kyoto, Japan
[6]Forestry and Forest Products Research Institute, Tsukuba, Japan

Understanding of global carbon cycles demands evaluation of the interaction between various terrestrial ecosystems and the atmosphere. Long-term observation of net ecosystem CO_2 exchange (NEE) has been performed by eddy covariance technique over various terrestrial ecosystems. Comparative studies of NEE have been advanced in America or Europe. However, reports that address the NEE for Asian ecosystems, which are affected by Asia monsoon, are few. In this study, we analyze the response of forest ecosystems to environment factors. The study sites are two larch forests (Laoshan (LSH), China and Tomakomai (TMK), northern Japan), two evergreen needle-leaf forests (Fujiyoshida (FJY), Kiryu (KEW), central Japan), deciduous needle-leaf forest (Takayama (TKY), central Japan) and tropical rain forest (Pasoh (PSO), Malaysia) and tropical seasonal forest (Sakaerat (SKR), Thailand).

Figure 1 shows relationships between half-hourly mean daytime NEE and PPFD for four months (June to September). Curves were fitted by the non-rectangular hyperbola equation, and maximum gross primary production at light saturation (P_{max}) (μmol m^{-2} s^{-1}), the initial slope (ϕ) (mol mol^{-1}), the convexity of the light-response curve (θ) and daytime respiration (RE_{day}) were obtained. The curves of the equation show the large difference between two tropical forests at low-latitude (PSO, SKR). It should be caused by the difference of vegetation, tree age, climate, and soil type. In contrast, for three mid-latitude forests in central Japan (TKY, FJY, KEW), their fitting curves almost overlapped in spite of different vegetation and environment. Although two curves for larch forests (LSH, TMK) show large difference because of different environment, both forests have common characteristics that P_{max} and RE_{day} were larger than other forests except for SKR.

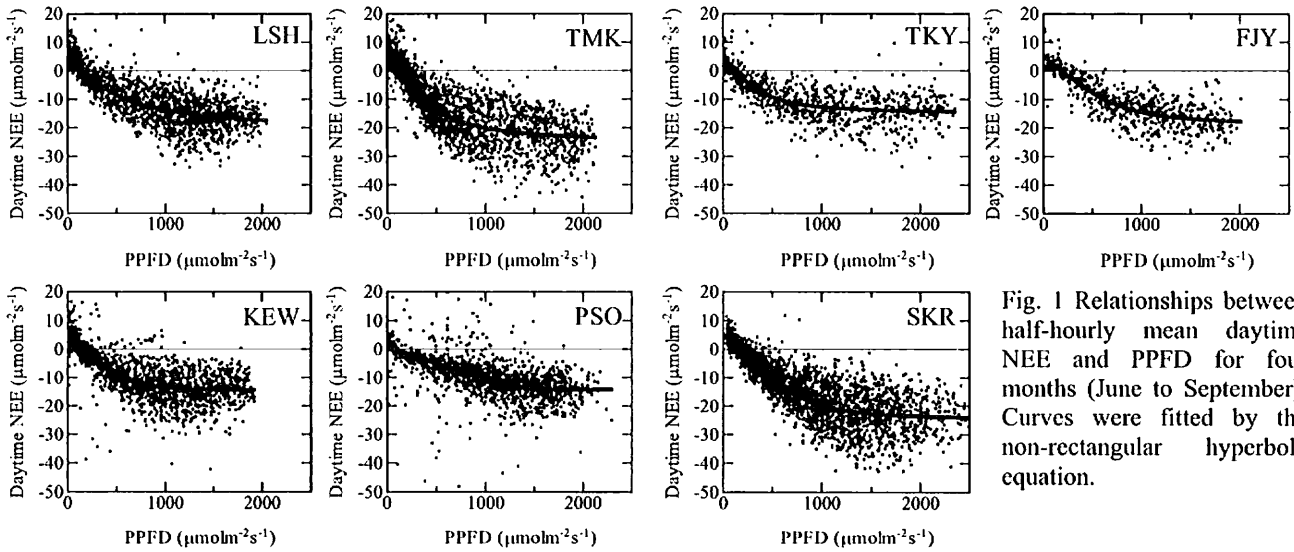

Fig. 1 Relationships between half-hourly mean daytime NEE and PPFD for four months (June to September). Curves were fitted by the non-rectangular hyperbola equation.

Acknowledgements: *This study was supported by Japan Ministry of Environment (Integrated study for terrestrial carbon management of Asia in the 21st century based on scientific advancements). The authors would like to thank all the project investigators, their co-workers, and students for providing data.*

P04

ANNUAL CARBON BUDGET OF A SINGLE-RICE CROPPING PADDY FIELD BASED ON LONG-TERM FLUX MEASUREMENT

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Rice paddy fields are agricultural ecosystem covering the largest land area in monsoon Asia. Although there are a variety of cropping patterns in rice paddy fields, single rice-cropping paddy fields widespread in northeast Asia are characterized by continuously flooded crop-growing season followed by a contrasting drained fallow period. Ecological conditions of paddy fields are basically controlled by human activities and exhibit drastic changes within each year. Carbon exchange between paddy fields and the atmosphere is also influenced by cultivation practices and field management. In this paper, annual carbon exchange at a customarily cultivated single rice-cropping paddy field in central Japan is presented based on results of measurement of carbon dioxide (CO_2) and methane (CH_4) fluxes combined with ecological measurement.

The present study was conducted at Mase paddy flux site (36° 03'N, 140° 02'E, 15 m asl). Rice is transplanted to the irrigated field at the beginning of May and harvested in mid-September. The field was flooded to a depth of 3 to 5 cm from late April to mid-August with temporary interruption by mid-season drainage. Harvest residue (rice straw and stubbles) was ploughed into soil. CO_2 flux density was measured by the standard eddy covariance method with an open-path infrared gas analyzer, while CH_4 flux density was determined by the modified aerodynamic method from the vertical gradient of CH_4 concentration.

CO_2 flux exhibited a distinct seasonal variation: uptake during the growing season and release during the fallow period. CO_2 flux showed a maximum uptake of 9 g C m^{-2} d^{-1} around heading period of rice. The field became a net source of CO_2 prior to the harvest due to declined photosynthetic fixation and increased soil respiration under drained field conditions. With a peak emission immediately after the harvest, release of CO_2 as small as 1 g C m^{-2} d^{-1} continued until the field was irrigated again in April. The annual net ecosystem CO_2 exchange (NEE) from 2002 to 2005 ranged between –130 and –290 g C m^{-2} y^{-1}. The interannual variability in NEE was caused by 1) changes in Gross Primary Production (GPP) influenced by the amount of incident solar radiation, 2) changes in soil respiration influenced by duration of drainage, and 3) changes in soil respiration during the fallow period influenced by temperature and length of the fallow period. CH_4 flux exhibited a commonly observed seasonal pattern. It showed a gradual increase from about 40 days after flooding, a temporary decrease during the mid-season drainage, and a flush of CH_4 stored in soil at the final drainage. Timing and magnitude of the flushes varied year by year depending on water management of the field and precipitation during the drained periods. The total amount of CH_4 released from the field in the growing season of 2003 to 2005 was 19.9, 19.1 and 11.4 g C m^{-2} $season^{-1}$, respectively. A long mid-season drainage in 2005 resulted in smaller amount of CH_4 emission than those in previous two years.

Carbon removed from the field at harvest was estimated between 200 and 260 g C m^{-2} depending on yield of rice. Previous studies conducted at the study site showed that the budget of water-dissolved carbon was almost balanced in the total of the irrigated period. The annual carbon budget of the filed estimated by including all of these components ranged between +30 (gain of carbon) and –90 g C m^{-2} y^{-1} (loss of carbon). The total carbon budget of the field was close to neutral on average, but its year-to-year variations exceeded 100 g C m^{-2} y^{-1}. Seasonal CH_4 emission from the field was only 3 to 5% (on molar basis) of the magnitude of NEE in the growing season. However, CH_4 emission is important in the greenhouse gas budget of the field when the global warming potential of CH_4 is taken into account. From the viewpoint of greenhouse gas exchange, the paddy ecosystem is more important as a source of CH_4 than as a sink of CO_2.

At the study site, unexpected downward CO_2 fluxes were often observed in the latter half of the fallow periods as is reported at other flux study sites where open-path eddy covariance system is employed. It is important to solve this problem to improve the estimate of annual NEE of the paddy field as the fallow period lasts for about two-thirds of a year. In order to understand how the paddy ecosystem in Asia affects the global carbon budget in total, observation at paddy fields with various cropping patterns is needed, such as double-rice and rice-wheat cropping paddy fields that are widespread in Asia. *This study was sponsored by the GWIP by MAFF, Japan, GERF (B-3, S-1) by ME, Japan and CSSPR (H12-10) by JST.*

P05

SEASONAL VARIATION OF CARBON DIOXIDE EXCHANGE AND ANNUAL CARBON BUDGET AT FOUR MANAGED GRASSLAND SITES IN JAPAN

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Grassland occupies 40.5% of the total land area in the world, and it is an important ecosystem to support herbivorous livestock production. Grassland is also important as a reservoir of organic carbon stock because of perennial plants dominating in grassland vegetation. In Japan, where grassland accounts for 13% of the total agricultural land area, 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. To promote the use of livestock excreta as manure to grassland, it is necessary to understand how manure application affects carbon budget in grassland ecosystem, taking the influence on the total greenhouse gas exchange into account. We started a field study to clarify the impact of manure application on carbon budget at four grassland sites located from cool temperate to warm temperate region in Japan (Fig. 1). At each site, adjoining two plots were provided for the experiment: one for stable manure application, and the other for chemical fertilizer application. Flux densities of carbon dioxide (CO_2) at both plots are monitored by the eddy covariance method using the same instruments and a common data processing method. In this paper, we place the focus on the chemical fertilizer plot at the four study sites, and present seasonal trend of CO_2 exchange and annual carbon budget at each site by using the results obtained from November 2004 to October 2005.

Observed NEP exhibited high-degree of seasonality and inter-site variability that are influenced by climate conditions and field management. At Nakashibetsu (NKS) site and Shizunai (SZN) site in northern Japan, the grassland was generally dormant in CO_2 exchange from November to April. At Nasushiobara (NSS) site in central Japan, diurnal variation of CO_2 flux was observed even in mid-winter, but daily NEP was close to zero, indicating photosynthetic CO_2 fixation was almost balanced by ecosystem respiration on daily basis. In contrast with these three sites, at Kobayashi (KBY) site in southwestern Japan, daily CO_2 uptake as much as 4 to 5 g C m^{-2} d^{-1} was observed continuously on clear days in winter. CO_2 exchange at all of the study sites was activated by the beginning of the growing season of grasses. NEP during the growing season repeated a gradual increase in net CO_2 uptake with growth of grasses followed by an abrupt change to CO_2 emission immediately after harvest of grasses. The annual NEP ranged from 2.7 Mg C m^{-2} y^{-1} at NKS to 6.4 Mg C m^{-2} y^{-1} at NSS. Interestingly, Net Biome Production (NBP) estimated by subtracting harvested carbon from the annual NEP was negative at two sites in cool temperate region (NKS and SZN), while NBP was positive at the other two sites in wamer region (NSS and KBY). This indicates that at NKS and SZN the total outflow of carbon from the grassland by harvest and decomposition of harvest residue and soil organic matters exceeded Net Primary Production (NPP) of the ecosystem.

This study was financially supported by Japan Grassland Agriculture and Forage Seed Association.

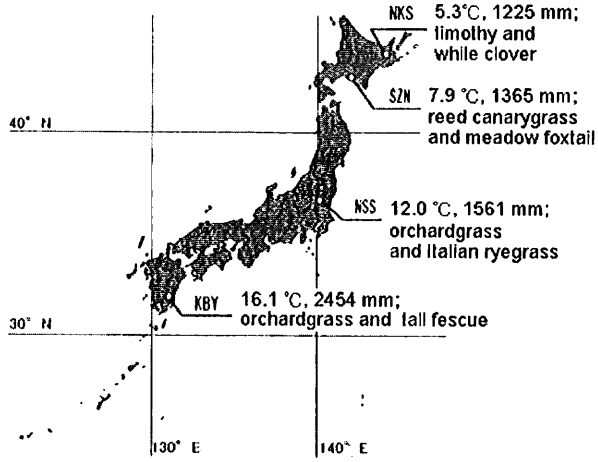

Fig. 1 Location of study sites with their annual mean air temperature, annual amount of precipitation and dominant species of grasses.

P06

SEASONAL AND INTER-ANNUAL VARIATIONS IN CARBON DIOXIDE EXCHANGE AT FIVE GRASSLAND AND CROP FIELD SITES IN EASTERN ASIA

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Carbon dioxide exchange in grassland and agricultural ecosystems in eastern Asia are discussed based on net ecosystem CO_2 exchange (NEE) and meteorological data obtained at five tower-based flux sites from 2002 to 2004. The study sites include alpine meadow on Tibetan Plateau (QHB), C3/C4 mixed grassland in central Japan (TGF), rice paddy in central (MSE) and western Japan (HCH), and a rotational forage (maize-Italian ryegrass) field in southwestern Japan (KON). We used the original datasets of half-hourly fluxes (15-minute fluxes for QHB) registered on a S-1 project database. After applying a common set of quality check to the original flux data, we applied the multiple imputation (MI) method semimonthly to fill up the gaps in the half-hourly NEE dataset, and estimated seasonal and annual sums of NEE. Half-hourly ecosystem respiration (RE) was also estimated by applying the MI method to the dataset composed of nighttime NEE, air temperature and friction velocity. Gross primary production (GPP) was calculated from the estimated NEE and RE. As an example, variations of estimated semimonthly NEE, GPP and RE at MSE are shown in Fig. 1.

At QHB, incident short-wave radiation (*Rs*) in early spring was a determining factor of the length of the growing season and the annual GPP. The soil moisture content had an obvious effect on the phase and the amplitude of GPP and RE. An extended dry period from beginning of July 2002, when the soil moisture content was lower by 0.1 m^3 m^{-3}, yielded smaller annual GPP and RE by 36% and 25%, respectively, than those in 2004. At the paddy sites (MSE, HCH), which were under the control of water management for rice cultivation, seasonal and inter-annual variations of GPP were influenced by *Rs* and timing of rice planting. Decreased *Rs* from June to July 2003 significantly influenced the annual GPP at MSE because the period of decreased *Rs* overlapped the first half of the growing season. Contrastingly, at HCH, influence of decreased *Rs* on GPP was more obvious in and after August 2004 than in June and July 2003 because the growing season of HCH was behind MSE by about 30 to 40 days. At MSE, the amplitude and the variation of RE during the growing season corresponded to the frequency and the length of mid-season drainage practices. At TGF, where observed CO_2 exchange during the growing season was quite different from the other study sites, closed vegetation (the maximum leaf area index exceeded 6.5) and dead grasses that were mown and left in the field previous year caused considerably large GPP and RE. At KON, continuous CO_2 uptake by the rotational forage field was observed almost throughout the year. At this site, a draught period accompanied by high vapor pressure deficit had decisive influence on magnitude of GPP. Although our study sites located in monsoon Asia are generally believed to be less water-stressed than European and North-American sites, the present results suggest that not only radiation but also dryness are key factors to investigate carbon dynamics on grassland and agricultural ecosystems in this region.

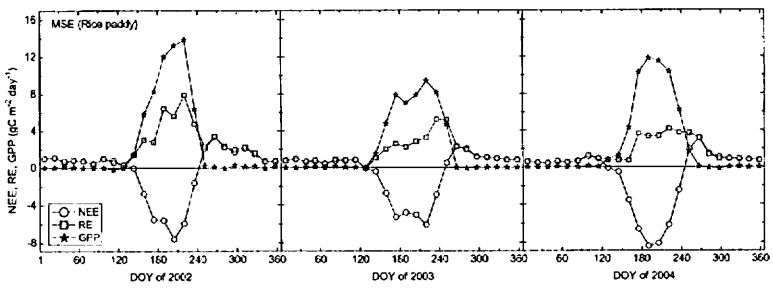

Fig. 1 An example of seasonal and inter-annual variations of semimonthly carbon budget components estimated by the MI method.

Acknowredgements
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P07

ENVIRONMENTAL CONTROLS ON CARBON BUDGETS IN TYPICAL GRASSLANDS IN CHINA

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Long-term measurements of CO_2, H_2O and heat fluxes between natural vegetation and atmosphere have facilitated the research on carbon cycle in terrestrial ecosystems and its response to global climatic changes. Based on flux measurements at five different grassland ecosystems, one semi-arid *Leymus chinensis* steppe in Inner Mongolia (NMG), an alpine meadow (BT), an alpine shrub-meadow (GCT), an alpine swamp-meadow (SD) at Haibei in Qinghai and a steppe-meadow at Dangxiong on Tibet Plateau, the dynamics of main processes of ecosystem CO_2 exchange in the five grassland ecosystems and their responses to environmental changes were investigated.

Located in different regions, there were significant differences in the climate, vegetation and soil type among the five grassland ecosystems, which result in their different response to environmental changes. The net ecosystem CO_2 exchange (NEE) in five grasslands showed large seasonal and interannual variation with the change of temperature, water availability and solar radiation. The four alpine meadows on Tibet Plateau mainly sequestrate carbon from June to September and emit carbon in other months. The NEE of NMG has biggest interannual variation due to the fluctuation in precipitation. The alpine meadow (BT), shrub-meadow (GCT) and swamp-meadow (SD) at Haibei have larger photosynthetic production (F_{GEP}) than the alpine steppe-meadow at DX and the semi-arid steppe at NMG. With abundant rainfall during growing season, the F_{GEP} of alpine ecosystems at Haibei was mainly limited by air temperature and solar radiation, while the F_{GEP} at DX showed significantly positive correlation with soil and air moisture. The frequent moisture stress has important effects on both F_{GEP} and ecosystem respiration (R_{eco}) at NMG site. The annual total ecosystem respiration of the five grassland ecosystems followed the order in BT>SD>GCT>NMG>DX. In arid and semi-arid ecosystems, soil water condition has important effects on R_{eco} and its response to temperature. Results indicated that temperature and water availability are main determinants of net ecosystem CO_2 exchange in all grassland ecosystems.

Comprehensive analysis shows that NMG, DX and SD sites were a net carbon source during the observing years, and the GCT and BT sites are net carbon sink. The global change with global warming and changes in precipitation could have profound effects on temperate and alpine grasslands in China.

Keywords: Eddy covariance, grassland ecosystem, alpine meadow, net ecosystem CO_2 exchange, ecosystem respiration

P08

STUDY ON THE RELATIONSHIP BETWEEN CO_2 FLUX AND H_2O FLUX IN PADDY FIELDS OF THILAND AND JAPAN

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There is high correlation between FCO_2 and FH_2O during all growth stages of paddy rice fields in Thailand as well as in Japan. Furthermore, FCO_2/FH_2O (CWFR) in each growth stage can be estimated by VPD, and then we could estimate CWFR by VPD in each growth stage (Pakoktom *et al*, 2004). If we can estimate the ratio of CWFR, then we can estimate CO_2 flux from H_2O flux which is relatively easy to calculate by using simple climatic data. In the present research, the further analysis was carried out using measured data sets of Japan in 2005.

Measurement

The measurements were conducted at a paddy field of Tokyo University of Agriculture and Technology, Fuchu city, in 2005. Flux densities of CO_2 and H_2O were measured during 4 stages of growth, LAI<1.5 (stage I), 1.5<LAI<4 (stage II), 4<LAI<6 (stage III) and ripening stage (stage IV) based on Bowen ratio technique. The relationship between FCO_2 and FH_2O, CWFR and climatic data were analyzed by regression analysis.

Results

The FCO_2 and FH_2O showed high correlation for all of VPD levels at all growth stages as shown in Fig. 1. Fig. 1 shows the correlation at stage III. The slope of the regression lines decreased when increasing VPD in a paddy field of Japan (fig 1A) as the same as in a paddy field of Thailand (Fig 1B).

The CWFR and VPD in a paddy field of Japan showed high correlation in all of growth stages as shown in Fig. 2. The trend of regression lines were decreased when increasing VPD at all of growth stages in a paddy field of Japan (see Fig.2) as the same as in a paddy field of Thailand.

Conclusion

A high correlation between FCO_2 and FH_2O during all growth stages and CWFR (FCO_2/FH_2O) in each growth stages had high correlation with VPD. Then it may be possible to estimate CWFR by VPD for both of paddy fields in Japan and Thailand.

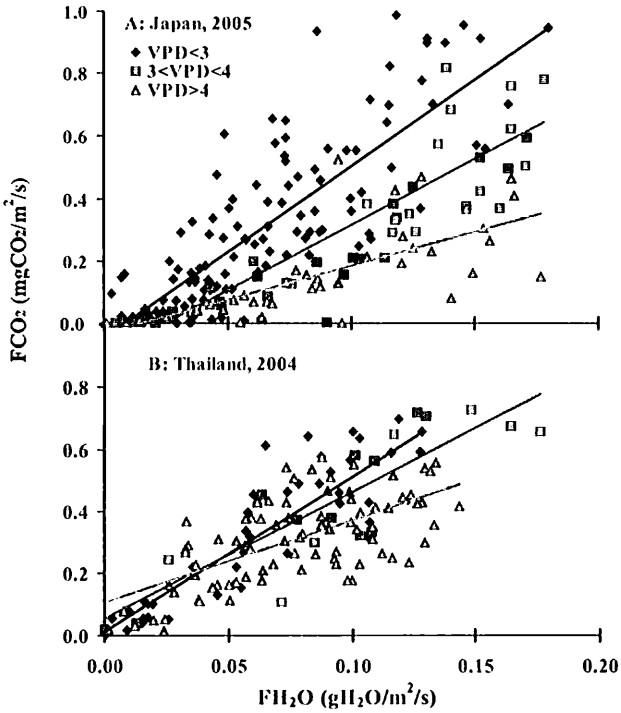

Fig. 1 Correlation between FH_2O and FCO_2 at each VPD level in a paddy field of Japan (A) and Thailand (B) for stage III

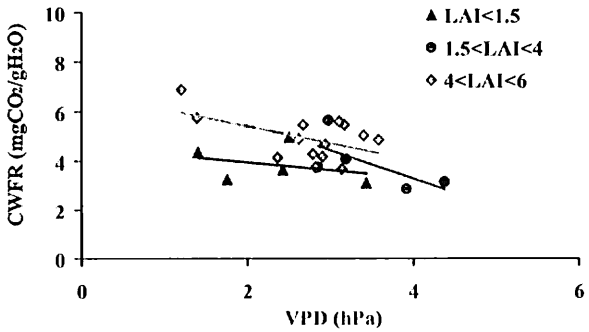

Fig. 2 Correlation between CWFR and VPD in each growth stage of Japan, 2005

P09

ANNUAL CARBON CYCLE OF *PINUS DENSIFLORA* STAND EVALUATED BY EDDY FLUX OBSERVATION AND ECOLOGICAL SURVEY

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Annual ecosystem carbon cycle of a broadleaf species mixed *Pinus densiflora* stand in Miki, Hyogo, Japan (34°47'N, 134°59'E) including flow among carbon compartments was evaluated based on the eddy flux observation and ecological survey during the period between December 2004 and December 2005. CO_2 flux above the forest was measured by means of the eddy covariance method. Meteorological conditions including photosynthetic photon flux density (PPFD), air and soil temperatures, soil water content etc. were also measured in the period. Linear trend removal for CO_2 concentration and WPL correction were applied for flux calculation and the less reliable data were removed by the stationarity, standard deviation and foot print test to produce the quality controlled half hourly datasets of CO_2 flux. The hyperbolic relationship between gross primary productivity (GPP) and PPFD, and the exponential relationship between ecosystem respiration (Re) and air temperature were determined simultaneously applying the genetic algorithm in monthly basis, and were used to fill the data gap of ecosystem CO_2 exchange and to evaluate monthly GPP and Re. Soil respiration was measured using two automatically ventilated closed chambers which were replaced biweekly. Above ground tree biomass and soil carbon content were measured in December of 2004 and 2005. Litter fall was collected in ten traps and the carbon content of litter was analyzed monthly.

Monthly mean air temperature reached its maximum in August, while monthly PPFD showed two peaks in May and August. Monthly Re and GPP showed similar seasonal courses to those of air temperature and PPFD, respectively. This difference in the seasonal courses of Re and GPP caused a unique seasonal course of net ecosystem productivity (NEP) which showed two peaks in May and October and the minimum in February. Monthly NEP was positive (CO_2 sink) throughout the observation period, and annual NEP was estimated to be 53 molC m^{-2} y^{-1}. The initial gradient of GPP to PPFD and the maximum GPP estimated by the hyperbolic model correlated to air temperature. Soil respiration rate was related to soil temperature and also moisture.

Above ground tree biomass evaluated by in situ survey was 276 and 287 molC m^{-2} in December of 2004 and 2005, respectively, and its annual growth was 9 molC m^{-2} y^{-1}. Total biomass including root was estimated by an allometric equation, and its annual growth was estimated to be 11 molC m^{-2} y^{-1} between 2004 and 2005. Annual litter fall of this period was 17 molC m^{-2} y^{-1} and the increase of soil organic matter was 5 molC m^{-2} y^{-1}. Annual heterotrophic respiration from soil evaluated as the difference between annual litter fall and annual soil organic matter rise was 12 molC m^{-2} y^{-1}. Annual net primary productivity (NPP) was calculated by summing annual tree biomass growth and litter fall, and was 28 molC m^{-2} y^{-1}. While NPP calculated by summing annual NEP from flux measurement and heterotrophic respiration was 64 molC m^{-2} y^{-1}, which was larger than NPP evaluated by the ecological survey. The estimated ratio of above and below ground tree respiration by using ecosystem, soil and heterotrophic respirations was 0.9 and was far smaller than the ratio of above and below ground biomass (4.5) in the allometric equation. These differences suggested the underestimation of Re, and/or over estimation of GPP and NEP by the flux measurement. This may be caused by the commonly reported tendency of CO_2 flux measured by the open-path eddy covariance systems. The result suggested the importance of validation employing different methods to evaluate ecosystem carbon cycle.

This study was supported by Japanese Ministry of Environment providing the grants "Strategy for the reproduction of natural and urban area in a basin."

P10

ENERGY, WATER, AND CO_2 FLUXES ABOVE GMELIN LARCH FOREST ON CONTINUOUS PERMAFROST OF CENTRAL SIBERIA

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We constructed a 20-m high tower made of wood (Fig.1) at a Gmelin larch forest, which is a principal ecosystem in continuous permafrost of Central Siberia. Heat, water vapor, and carbon dioxide fluxes were measured at the top of the tower during a growing season from June to early September, using the eddy covariance technique. Micro-meteorological variables as air temperature, humidity, wind speed and direction, radiations, soil temperature and moisture, were measured to support the eddy flux measurements.

The study site was an even-aged *Larix gemelinii* forest, near Tura in Evenki region, central Siberia (64°12'N, 100°27'E, 250 m a.s.l.). The forest trees formed open canopy structure, where canopy closure index was bellow 0.4 $m^2 m^{-2}$.

Monthly mean air temperature for the study period was higher in June but lower in July and August than the stationary 30-year averages. Monthly precipitation was half in June but was almost same in July and August of the long-term averages. Air temperature averaged 13.5°C through the measurement period (105 days) and total precipitation was 125.5 mm for the whole measurement period.

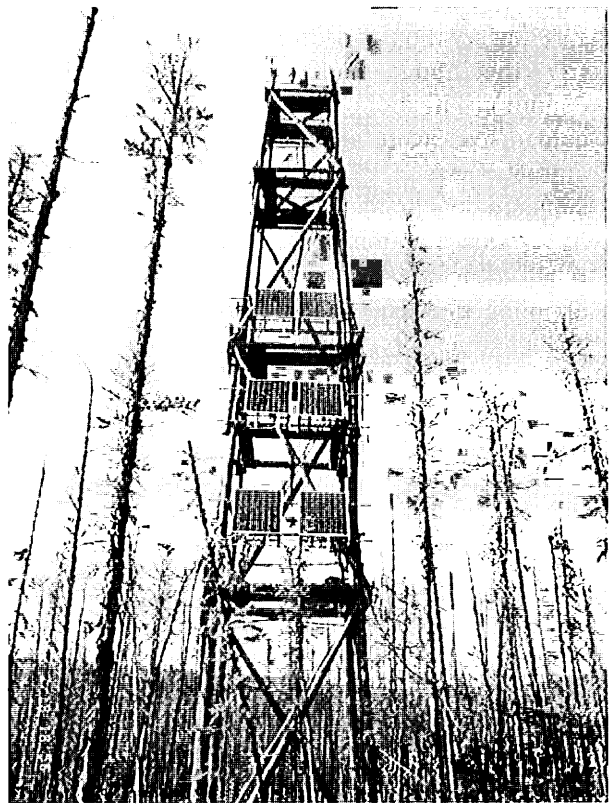

Fig.1 The meteorological tower equipped with solar panels

The sum of the eddy covariance heat and vapor fluxes occupied about 80% of net radiation on daily basis. During the growing season, mid-day mean daily shortwave and PPFD albedo values were lower compared with grass and tundra ecosystems. Values of mid-day mean daily Bowen ratio ranged approximately between 1 and 2, being relatively higher at the beginning and at the end of the growing period. Sensible heat fluxes responded to changes in incident radiation more sensitively than water vapor fluxes. Cumulative evapotranspiration slightly exceeded the total precipitation for 81 days of the growing period. Slight absorption of carbon dioxide by the ecosystem was observed during daytime even in early June when the larch trees were developing needle leaves and when the soil surface was snow-free but still frozen. The maximum half-hourly net uptake of carbon dioxide was observed between late June and early August. In early September, the ecosystem became the source of CO_2 in daily basis when the needles were still alive but began to change colors to yellow. The seasonal variation in the net uptake of CO_2 was primarily related to needle phenology of the larch trees. The magnitude of net uptake and release of CO_2 at the larch ecosystem was relatively low compared with other boreal forests and even with other larch forests on the continuous permafrost near Yakutsk.

P11

LONG-TERM VARIABILITY OF NET ECOSYSTEM PRODUCTION OF FUJIYOSIDA SITE ESTIMATED BY AMEDAS DATA - RESPONSE TO FLUCTUATING METEOROLOGICAL CONDITIONS OVER 30 YEARS -

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A tower was constructed at the northern foot of Mt. Fuji (Fujiyoshida forest meteorology site: Fig.1) and CO_2 flux monitoring started in 1999. Fujiyoshida site (35°27'N, 138°46'E, 1030m in elevation) is located on a gentle slope in a cool temperate region of central Japan. The dominant species of the site are Japanese red pine (*Pinus densiflora*) at the upper canopy and Japanese holly (*Ilex pedunculosa*) at the lower canopy. The soil is composed of volcanic lava and covered partially with litter and organic matter.

CO_2 flux has been measured by eddy covariance method using a three-dimensional sonic anemometer (SAT; DA600/KAIJO) and an infrared gas analyzer (IRGA; LI-6262/LI-COR). The SAT was set at a height of 26m on the tower, which is about 6m above the mean canopy height (Fig.2). The air is drawn at the same height by an air pump to the IRGA and the CO_2 concentration is analyzed.

The net ecosystem CO_2 exchange (NEE) was calculated every 30 minutes, taking account of CO_2 storage change within the canopy. Within this method, three-dimensional axis rotation (McMillen, 1988), corrections of the effects of lateral wind and water vapor on sonic velocity (Kaimal et al., 1968), and WPL correction (Webb et al., 1980) were employed. Then the data quality control tests (QC) were put into practice to check for inadequate data. The QC procedure followed Foken and Wichura (1996) and Vickers and Mahrt (1997).

The nighttime NEE was parameterized by air temperature. It equals ecosystem respiration (*Re*). Gross ecosystem assimilation (*Ag*) was calculated using the relationship: $Ag = -NEE+Re$. *Ag* was parameterized by absorbed photosynthetically active radiation (APAR).

The meteorological data have been measured at Kawaguchiko weather station (AMeDAS) for more than 30 years (Fig.3). The station (35°30'N, 138°46'E, 860m in elevation) is about 5km north of the Fujiyoshida site. The air temperature and APAR of the Fujiyoshida site was estimated by the meteorological data of the weather station. Then, the annual NEP (Net Ecosystem production: NEP= negative NEE) for 30 years was estimated by the above relationship using the meteorological data, assuming that the condition in the forest did not change.

This presentation shows the characteristics of the variability of the annual NEP in Fujiyosida site.

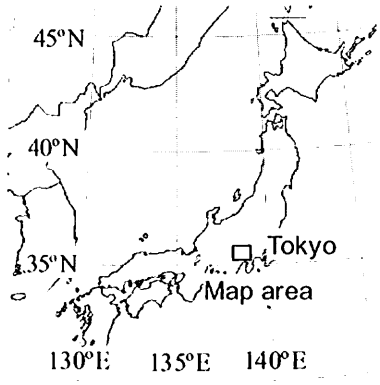

Fig.1 Location of Fujiyoshida forest meteorology site

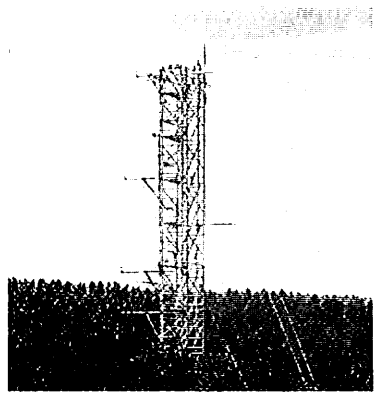

Fig.2 Tower at Fujiyoshida site

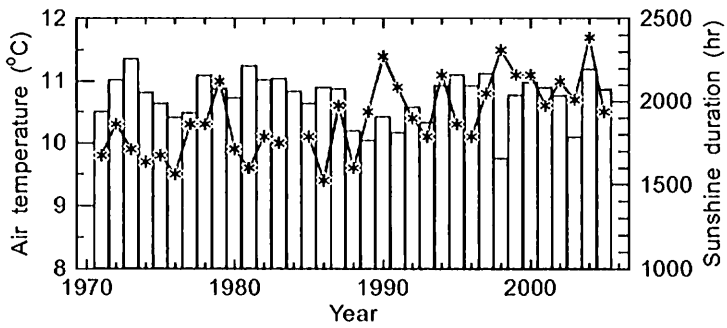

Fig.3 Annual mean air temperature and annual sunshine duration of Kawaguchiko weather station (Meteorological Agency)

P12

CO_2 AND WATER VAPOUR FLUXES AT A SUBTROPICAL MONTANE CLOUD FOREST ECOSYSTEM IN NORTH-EASTERN TAIWAN

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From 04 August through 27 September 2006, an eddy covariance setup was installed within a subtropical montane forest ecosystem to study the turbulent vertical fluxes of CO_2 and water vapour. To our knowledge, this is the unique eddy covariance site in Taiwan due to high micrometeorological requirements concerning the experimental site. The study site is part of Taiwan's Long Term Ecological Research sites which is supported by the Taiwan National Science Council in cooperation with the Taiwan Forest Research Institute. Scope of the program is to research the ecological processes with regard to hydrological and biogeochemical cycles of the ecosystem.

The experiment was carried out in a partly managed forest plantation where the tree canopy is considerably closed and uniform and the average height is 13.7 m. The meteorological tower is situated within a valley on a relatively flat section which slopes with an angle of 15° towards south east. The eddy covariance setup consisted of a Young 81000 sonic anemometer and a LI-COR 7500 combined infrared CO_2/H_2O-analyzer (12.5 Hz sample frequency) which was installed at the uppermost platform at 23.4 m.

In this study we examine the influence of fog on the vertical fluxes of CO_2 and water vapour and hence on the microclimate of the endemic cypress forest. A pronounced diurnal wind regime dominates with valley winds from S to SE during the day and downhill winds from N to NW at night. The presence of fog is strongly related to wind directions from SE and S. The occurrence of fog at the study site is very frequent with an average duration of 4.7 to 11 hours per day. During about 25 % of the experimental period, foggy conditions (visibility < 1000 m) were prevailing. Fog affects the physiological conditions of the plants (*Chamaecyparis obtusa var. formosana* and *Chamaecyparis formosensis*) by high air humidity and strong reduction of incoming shortwave solar radiation. Therefore, not only the leaf metabolism but also the development of flowers or fruits for reproduction is influenced. Moreover, a reduced mineral uptake by plants is associated with the minor rate of transpiration during foggy conditions.

The measurements took place in mountainous and rather non-ideal terrain for the eddy covariance approach. Moreover, the presence of fog causes large instrumental difficulties since the optical and sonic measurement techniques are often obstructed by water droplets on the sensing devices. Special effort was employed on quality assurance of the flux data. Only data during steady-state conditions during the 30-min averaging intervals, simultaneously exhibiting a well developed turbulence regime, were used for the calculations of turbulent fluxes. The extent of atmospheric turbulence was determined with help of the friction velocity u*, and the integral turbulence characteristic ITC. In particular during nighttimes, when atmospheric layering was stabile and the turbulence regime poorly developed, the measured fluxes were small. The examination u* lead to the hypothesis that advective downhill fluxes associated with positive momentum flux, e.g. drag from below the canopy occurred at nighttime.

A footprint analysis was applied to evaluate the fluxes and data quality regarding the changing topography and fetch properties of the study site depending on wind direction. A source weight function based on the Eulerian approach was used to identify the surface area influencing the flux measurements. The footprint calculation shows excellent fetch conditions for flux measurements for winds from south easterly direction.

The 30 min averages of CO_2 fluxes ranged between -52.5 µmol m^{-2} s^{-1} and +18.1 µmol m^{-2} s^{-1}, and the median was +2.6 µmol m^{-2} s^{-1}. The net CO_2 flux is hence assumed to be positive, e.g. directed upward. The fluxes proceeded in a pronounced diurnal cycle with negative values for the CO_2 fluxes during daytime representing CO_2 uptake by the plants. At night, CO_2 fluxes were positive, e.g. directed upward resulting from respiration. During foggy conditions, the CO_2 fluxes of both directions were considerably reduced. The water vapour fluxes showed an opposite diurnal pattern with maximum positive values at daytime and minor or even negative fluxes during night times. It ranged between -3.2 mmol m^{-2} s^{-1} and +6.7 mmol m^{-2} s^{-1} with a median flux of +0.9 mmol m^{-2} s^{-1}.

P13

CO_2 FLUX IN TROPICAL AREA IN SOUTHEAST ASIA MEASURED WITH EDDY COVARIANCE METHOD

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We have been observed CO_2 flux at 45 m tower in the Sakaerat Environmental Research Station (here after abbreviated by SKR), Nakhon Ratchasima, Thailand (14°29'29''N, 101°55'05''E, elevation 535 m.a.s.l.) and other two sites in tropical area since 2001. Gamo et al. (2005) reported that the -NEE estimated by eddy covariance method at the top of the tower at SKR in a whole year took a too big value, which cannot be explained with census data analysis. Figure 1 shows the wind rose at the tower in 2004 at SKR. Most of the wind direction is SW, and NE wind appears only in short time during dry season. The nighttime NEE does not increase as temperature rises, because there is clear correlation between temperature and vapor pressure depression (Figure 2).

Figure 3 shows an example of monthly averaged daily variation of CO^2 concentration at the four levels on the tower in June, 2003. This figure suggests there is not so big storage of CO_2 in the canopy and not small amount of CO_2 outflows from the community without being detected by eddy covariance equipments.

Since the surface around SKR is inclined by 6 %, the CO_2 may flow out as drainage flow in the understory in the canopy at night. Takayama site in central Japan is located on a hilltop, and we setup a new 20m tower in a small valley there, the inclination of the slope is approximately 40%. The profile observation at the Takayama tower showed that drainage flow in the understory is generated soon after the sunset and CO_2 rich airmass is restricted below the layer 6 m above the ground. Similar process might be worked in the tropical forests.

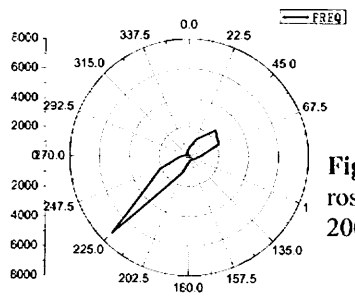

Figure 1 Wind rose at SKR in 2004.

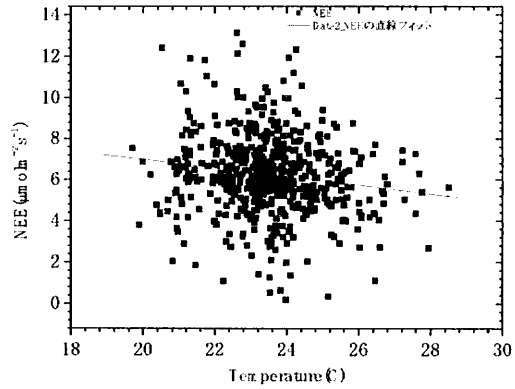

Figure 2 The relation between temperature at 5m above the ground and night time NEE at SKR, wet season in 2004 (for u* > 0.8m/s).

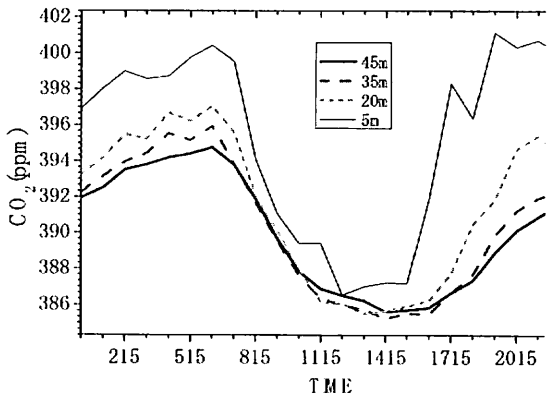

Figure 3 Monthly averaged daily course of CO_2 concentration at SKR, June 2003.

Reference

Gamo, M. et al., 2005: Proceedings of AsiaFlux Workshop 2005, Fujiyoshida, pp.86.

P14

EFFECTS OF MANURE APPLICATION ON CARBON BUDGET OVER MANAGED GRASSLAND IN CENTRAL JAPAN

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In order to investigate the effects of manure application on carbon budget over managed grassland, field experiment has been conducted. The eddy covariance measurements of carbon dioxide (CO_2) were made from September 2004 to August 2006 at grassland in National Institute of Livestock and Grassland Science (NILGS), Nasushiobara, Japan (36°55'N, 139°58'E, 320 m a.s.l.). The annual temperature and precipitation of the experimental site are 12.0°C and 1561 mm, respectively. The vegetation is dominated by orchardgrass (*Dactylis glomerata* L.) and Italian ryegrass (*Lolium multiflorum* Lam.), and the grasses are harvested four times a year.

At the grassland two contiguous plots were provided for the experiment, one for manure application (M-plot) and the other for chemical fertilizer application (F-plot). Composted cattle manure was applied on M-plot after the last harvest of each year (mid-November, 15 Mg ha^{-1} in 2004 and 32 Mg ha^{-1} in 2005). Fluxes of CO_2 were measured with the eddy covariance system, which consisted of a sonic anemometer (CSAT3, Campbell Scientific) and an open-path infrared gas analyzer (LI-7500, LI-COR). The system was installed at each plot with instruments to measure other meteorological variables.

Seasonal trends in CO_2 flux (F_c) of the two plots were similar throughout the observation period: F_c of both plots were kept almost zero during winter season, and, from mid-March, increase of CO_2 uptake with growth of grasses and temporal CO_2 release after harvest were observed. However, in summer season when the temperature was high, values of F_c between the plots were somewhat different: F_c of M-plot shifted toward CO_2 release, especially in 2006.

Each year net biome production (NBP), which represents carbon budget in terrestrial ecosystem, was calculated as a sum of carbon in the net ecosystem production (NEP), exported carbon through grass harvest (C_H) and imported carbon through manure application (C_M). In the first year, integrated value of NEP was larger than C_H in both plots. While NEP was smaller in M-plot than in F-plot, NBP of M-plot was larger than that of F-plot by 0.48 Mg C ha^{-1} due to carbon input through manure application. In the second year, NEP was smaller than C_H in both plots and, manure application taken into account, NBP of M-plot was larger than that of F-plot by 3.68 Mg C ha^{-1}.

Although manure applied on the grassland in autumn was suggested to be decomposed and more CO_2 was released from M-plot than from F-plot during summer season, this study showed that manure application can increase the amount of carbon sequestered to managed grassland in central Japan.

This study was conducted as a part of "Establishment of Good Practices to Mitigate Greenhouse Gas Emissions from Japanese Grasslands", which was organized by Japan Grassland Agriculture and Forage Seed Association and funded by Japan Racing and Livestock Promotion Foundation.

Table Annual carbon budget of the experimental plots

Year	Plot	Carbon budget (Mg C ha^{-1})			
		NEP	C_H	C_M	NBP*
2004-2005†	M-plot	5.27	4.81	1.85	2.32
	F-plot	6.36	4.53	0.00	1.84
2005-2006‡	M-plot	2.72	3.06	3.79	3.45
	F-plot	2.40	2.63	0.00	-0.23

* NBP = NEP - C_H + C_M
† Integrated value from the last harvest of 2004 to the last harvest of 2005 (373 days).
‡ Integrated value from the last harvest of 2005 to the second harvest of 2006 (241 days).

P15

EVAPORATION AND CO_2 EXCHANGE IN MAIZE FIELDS IN SHANXI PROVINCE, CHINA

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We report on collaborative studies of water use and water use efficiency by maize crops conducted in 2005 and 2006 in Shanxi Province, China. The area is semi-arid and crops are irrigated. A micrometeorological flux station has been established in the midst of farmland in Yuci County. In both years, the site has been surrounded by extensive maize fields. Instrumentation includes a 3-D sonic anemometer, an open-path CO_2/H_2O gas analyser, a net radiometer, soil heat flux plates, soil thermometers, soil moisture probes and a recording rain gauge. The instruments and data logger are powered from batteries connected to solar panels. Relevant fluxes of energy, momentum, heat, water vapour, CO_2, and supporting information are measured continuously in 30-min runs. In 2005, measurements were made from May 20 to October 6, covering the period from planting to near maturity. In 2006, measurements were made over a similar period from May 5 to September 26. Highlights have been:

- Energy closure is quite satisfactory, giving confidence in the eddy covariance system. Regressions of the sum of sensible and latent heat (uncorrected for sensor separation or low u_*) on the available energy yielded a regression coefficient of 0.88 with an r^2 value of .853 in 2005 and a coefficient of 0.94 and an r^2 of 0.832 in 2006.
- Evaporation rates were high, averaging 3.2 mm d^{-1} for the whole growing season in 2005 and 2.6 mm d^{-1} in 2006. Maximum rates exceeded 5 mm d^{-1} in both years.
- Total water use was estimated at 440mm over 144 days in 2005 and 374mm over 140 days in 2006.
- Crop CO_2 exchange rates were similarly high, with 24-h averages of -0.17 mg CO_2 m^{-2} d^{-1} for the whole of the growing season in both years. Maximum sequestration rates were near 50g m^{-2} d^{-1}.
- Equilibrium evaporation, E_{eq}(= (s/(s+γ) (R-G_0)),was a good predictor of actual evaporation. Regression analysis yielded $\lambda E = 1.09E_{eq}$, $r^2 = 0.850$ in 2005 and $\lambda E = 1.17E_{eq}$, $r^2 = 0.825$ in 2006.
- Crop CO_2 exchange was closely linked to crop evaporation. For the hours of 0700-1800, water use efficiency, F_c/E, was -3.886 μmol $mmol^{-1}$, with an r^2 value of 0.688 in 2005 and was -3.542 μmol $mmol^{-1}$, with an r^2 of 0.604 in 2006.

The project is yielding valuable basic data for a main cereal crop in the North China Plain.

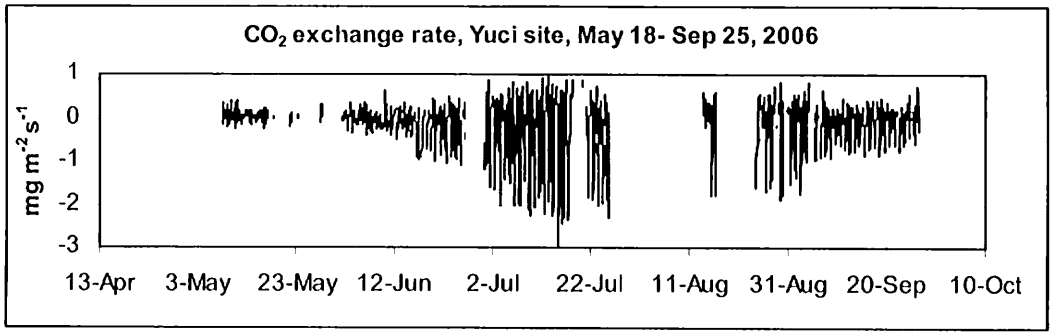

Fig 1. Example CO_2 fluxes. CO_2 exchange shifts from positive to negative as the crop grows.

P16

MICROMETEOROLOGICAL MEASUREMENTS OF GAS EXCHANGE BY SUGARCANE

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Sugarcane is a high-producing tropical crop, but although much studied, there is little documentation of gas exchanges with the atmosphere. High CO_2 assimilation rates are expected because sugarcane is a C4 plant, and high evaporation rates because the crop is grown in wet tropical and sub-tropical regions. However, the high use of nitrogen fertilisers in its production and the same environmental conditions are also conducive to the production and emission of nitrogen gases, most notably the greenhouse gas nitrous oxide, N_2O. We report first results from a project to determine the magnitudes and seasonal patterns of gas exchange from Australian sugarcane crops. Fluxes have been measured using micrometeorological and chamber techniques for the whole of the 2005/2006 growing season on a ratoon crop growing on an acid sulfate soil at Murwillumbah (latitude 28°S) on Australia's east coast. An account will be given of the measurement techniques employed and results from the first year's investigations will be presented. Some notable outcomes of the study are:

- The average CO_2 exchange rate for the growing season was 31.7 g m^{-2} s^{-1}, but soil respiration measurements indicated that net assimilation rates were much higher, approaching 50 g $m^{-2}s^{-1}$
- Over the 350 days of the study, evaporation from the cane averaged 3.1mm d^{-1} for a total evaporation of 1089 mm
- Rainfall for the period was 1879 mm
- The soil was thus frequently wet
- Emissions of N_2O from fields fertilised with 160 kgN ha^{-1} as urea have been large, totalling 41 kgN ha^{-1} over the 350 days; they were greatly stimulated by high soil moisture contents
- Emissions from the unfertilized soil have also been large, amounting to 20 kgN ha^{-1}
- Emissions from the fertilizer thus constituted 13% of the N applied
- This contrasts with the figure of 1.25% commonly used in greenhouse gas inventories
- Net sequestration of CO_2 by the crop from the atmosphere was 110 t ha^{-1}, while the emission of N_2O was equivalent to 20 t ha^{-1} of CO_2.

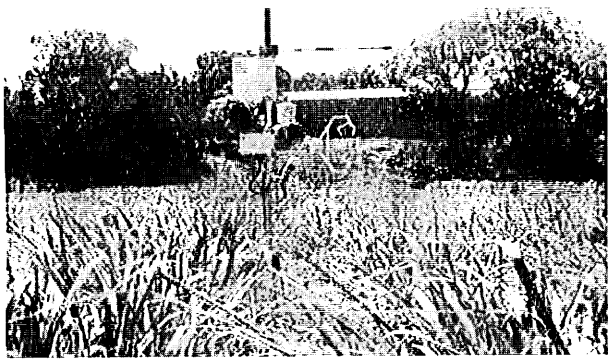

Fig.1. Eddy covariance equipment in sugarcane crop 2m high.

P17

SEASONAL AND INTERANNUAL CHARACTERISTICS AT RAIN-FED PADDY FIELD, THAILAND

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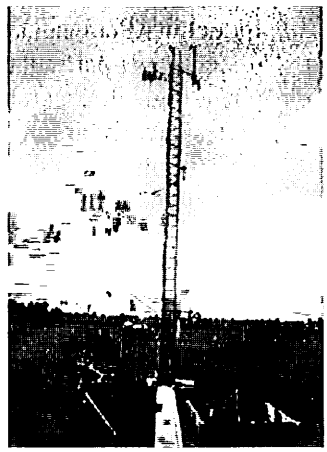

Fig.1 Flux observation site at rain-fed paddy field

To understand surface energy and water balance over paddy field which is main crop in Tropics is pivotal in investigating the interaction between vegetation and atmosphere. Rain-fed paddy field, Sukhothai (17°04′N, 99°42′E, 194 m asl, Fig.1) located at Chaophraya river basin, which is one of the measurement sites as the framework of the GEWEX Asian Monsoon Experiment-Tropics (GAME-T) was selected for measuring heat and water vapor exchanges between biosphere and atmosphere in time and in space using a micrometeorological fluxes measurement method. Sensors were installed on a 10m high tower to measure evapotranspiration (ET), sensible/latent heat flux and micrometeorological data since March 1997. The 7-year data observed continuously by GAME-T at Sukhothai rain-fed paddy field (1999-2005) were analyzed.

From data analysis using hydrologic equation,

(Precipitation) - (submerge water) - (evapotranspiration) = (infiltration) + (runoff) - (influent) *(eq.1)*

it was found the possibility that significant quantities of water may inflow to paddy field (Fig.2). For more understanding water budget, further survey is necessary to figure out the component of the surface water level at rain-fed paddy field in Thailand.

From flux observations, it was found that the submerge water have a significant impact on heat budget (Fig.3). However, it was found that measured data included imbalance which corresponds to 0-30 % of Rn. For more understanding surface energy balance, further systematic research is necessary to figure out the cause of flux imbalance.

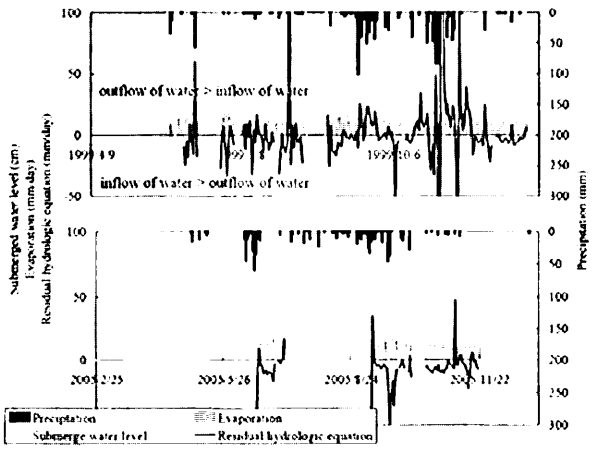

Fig.2 The transitions of the residual hydrologic equation, submerge water level and evaporation in 1999 and 2005.

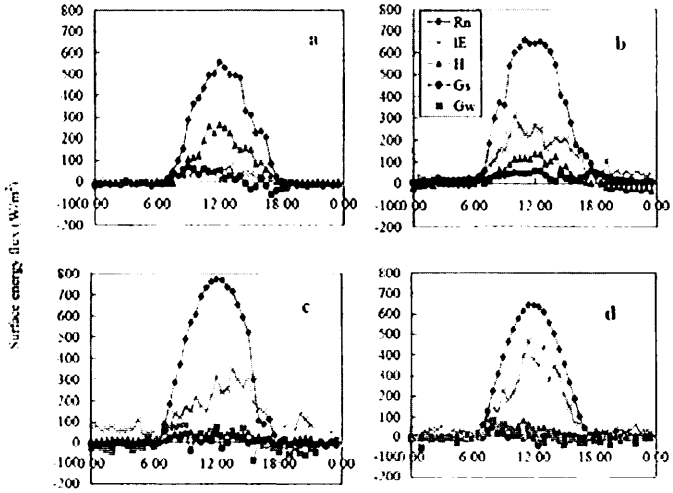

Fig.3 The diurnal change of surface energy flux
a) Feb 10, 2006 b) August 24, 2005 c) September 24,2005 d) October 22, 2005 Rn: net radiation, lE: latent heat flux, H: sensible heat, Gs: surface heat flux in soil, Gw: surface heat flux in water

P18

SEASONAL VARIATIONS IN HEAT AND CARBON EXCHANGES OVER A TEAK DECIDUOUS FOREST IN A TROPICAL MONSOON ENVIRONMENT: A COMPARISON BETWEEN FLUX DATA AND TREE PHENOLOGY

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Energy and carbon exchanges between the biosphere and atmosphere are strongly coupled both with the regional dynamics of climate and atmospheric carbon balance. Significant roles of forest vegetation within regional climate systems have been demonstrated using a regional climate model in inland areas of Indochina Peninsula. The ecological and hydro-meteorological roles of these forests are, however, poorly understood particularly with regard to seasonally dry deciduous forests in the region. Recently, phenological research in a teak deciduous forest in the region revealed that annual growing season length varies greatly among years probably due to inter-annual changes in the seasonal distribution of rainfall. This implies that energy partitioning and carbon exchange in deciduous forests in a tropical monsoon environment fluctuate between years, depending upon the rain-induced inter-annual variation in vegetative tree phenology. We established a flux tower in a teak deciduous forest in Mae Moh plantation, northern Thailand, for the purpose of understanding the seasonal and inter-annual changes in energy and carbon exchange in response to leaf phenology. With this in mind, the current study 1) reports seasonal changes in energy partitioning and carbon exchanges based on the eddy covariance approach, and 2) compares the seasonal changes with tree phenology such as changes in the leaf area index (LAI) and sap flow velocities of dominant trees. The exchanges of energy and CO2 were monitored using an ultra sonic anemometer (USA-1, METEK) and an openpass CO2/H2O analyzer (LI-7500, Li-Cor) mounted on a 40-m tower, as well as the storage flux within the canopy. Sap flow velocities of several teak trees were measured at a nearby site. Seasonal changes in LAI were estimated by transmittance of incident radiation through the canopy, which exponentially decreases with increasing LAI.

Net radiation energy was relatively constant throughout the study period (from October 2005 to July 2006). As expected, latent heat exchange above the canopy was generally high in the growing season and low in the dormant season, while sensible heat exchange was low in the growing season and high in the dormant season. The sap flow velocities declined approximately 1 month earlier than leaf-shedding of the teak trees. The decline in latent heat transfer to the atmosphere coincided more with the decrease in sap flow velocities than leaf shedding, while in contrast, activated latent heat exchange was occasionally observed from the leafless season to the beginning of the leaf-out season. This was likely caused by evaporation form the soil, which was wetted due to rainfall in the pre-monsoon season. Uptake of CO2 in the daytime was largest in the mid-growing season (June and July) and lowest in the late dormant season (February and March). Slight daytime uptake of CO2 was observed in the late dry season despite the fact that the studied forest is fully deciduous with only a few evergreen trees and shrubs. In conclusion, this study revealed distinct seasonal variation in energy and carbon exchange in response to the seasonal change in LAI in a deciduous teak forest in northern Thailand. Our results suggest that the large inter-annual variation in vegetative phenology will cause large fluctuations in the annual energy and carbon budget of deciduous forests in tropical monsoon regions.

Seasonal variation of CO_2 flux and its comparison with biomass measurement at a rice paddy field in Japan

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Rice paddy field is one of the most popular cultivation patterns in East Asia under a monsoon climate, which takes a great important role in CO_2 uptake. From this view, measurements of the Net Ecosystem Production (NEP=-NEE: Net Ecosystem Exchange) were conducted using eddy covariance method at several paddy fields. And the results were compared with Net Primary Production (NPP) estimated from biomass measurement.

In this study, measurements were conducted at the Hachihama experimental farm of Okayama University, Japan (34°32'16"N, 133°55'39"E, 2m a.s.l.) during growing season in 2005 and 2006. NEE was estimated after quality check and gap filling data obtained by eddy covariance method. Quality tests were applied in order to check the validity of the data and to eliminate erroneous data, and Gross Primary Production (GPP) and Respiration (Re) were separated by Non-Linear Regression Method. Nighttime Re (NEE in nighttime) was fitted by an exponential function of temperature and it was applied to the daytime Re, and also GPP was expressed as a rectangular hyperbolic function of incident PAR. Biomass was sampled on budding and at 2-weaks intervals until harvest in both years. Samples were clipped to above and below ground biomass from two 0.5m×0.6m plots randomly located in the field. Weights of samples were measured after dry process of 100°C at the first 2 hours and the next 48 hours by 80°C. Then, total biomass in carbon was estimated dry weight multiply by rate of carbon content. Rice paddy field, which has flat, relatively homogeneous canopy density and short canopy height, is suitable for applications with eddy covariance method, and biomass measurement in paddy fields is easier than that of forest ecosystems. Therefore, we can evaluate the integrated value of NEP in growing season through the comparison with NPP estimated from biomass measurement and heterotrophic respiration.

Using these data, we obtained the following results in 2005: (1) Rice paddy field was a source of CO_2 for the first 27 days of the growing period. NEE in 2005 was turned negative on 13 June, and decreased until maximum CO_2 uptake about 35 $gCO_2\ m^{-2}\ d^{-1}$ at 6 August as shown in Fig.1. Then, NEE was gradually increased and turned positive before harvest, (2) GPP, Re, and NEP integrated over the growing period in 2005 were 2979, 1385, and 1594 $gCO_2\ m^{-2}$, respectively and (3) Total biomass increased gradually and reached 638 gC m^{-2}, and cumulative NEP before harvest was 483 gC m^{-2} in 2005 as shown in Fig.2. In the lecture, we will explain about the results in 2006 and discuss about the differences in 2005 and 2006.

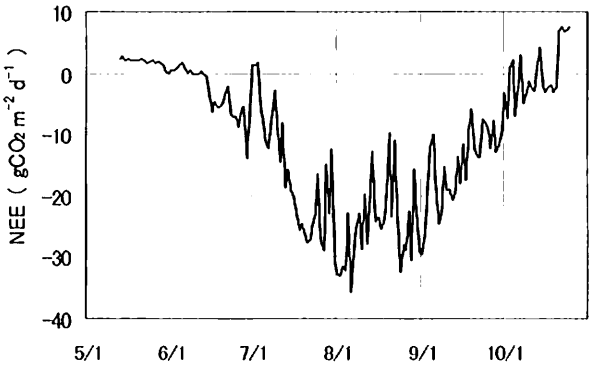

Fig.1 Temporal variation of NEE during glowing season in 2005.

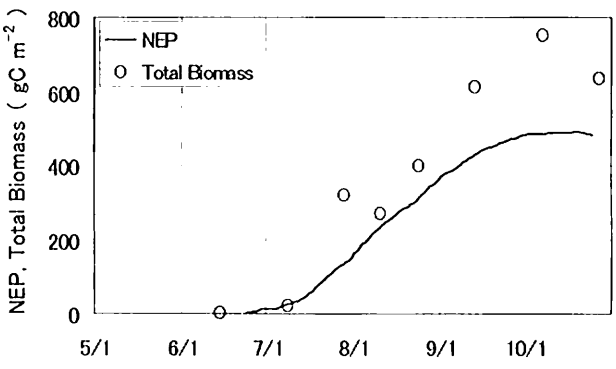

Fig.2 Comparison of integrated NEP with total biomass during glowing season in 2005.

P20

UNDERSTANDING OF WATER AND CARBON EXCHANGES IN GWANGNEUNG FOREST, KOREA IN 2003 AND 2004 BASED ON INTERDISCIPLINARY APPROACHES

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Precipitation in 2003 and 2004 showed a significant difference in magnitude and pattern and accordingly made an impact on the temporal variation of radiation and air/soil temperature in Gwangneung forest. The greater amounts of precipitation in 2003 resulted in the absence of a typical dry spell during the early and late growing seasons. We report water and carbon exchange based on interdisciplinary approach conducted by CarboKorea and HydroKorea projects. We conducted various measurements and analyses such as micrometeorological, chamber, leaf carbon isotope, leaf nitrogen content, biometric, and satellite data. Based on the measured *NEE* and *PAR*, the light use efficiency (*LUE*) was compared for the two years. Due to frequent power and instrument failures in 2004, the tower flux data were available only from 28 May to 14 June during the growing season. The α (initial slope) was similar in both years with values ranging from 0.4 ~ 0.5. However, maximum CO_2 flux (NEE_{max}) was smaller in 2004 (32 ~ 54 μ molm^{-2}s^{-1}) than in 2003 (45 ~ 61 μ molm^{-2}s^{-1}). The chamber measurements of soil CO_2 efflux indicated a significant reduction (~20%) of soil respiration in 2004 compared to that in 2003. Soil CO_2 efflux from May to October was 618 g C m^{-2} in 2003 and 477 g C m^{-2} in 2004. Seasonally averaged carbon isotope discrimination (Δ) of *Quercus serrata* (konara oak) leaves grown at the canopy top was 18.7±0.5 ‰ in 2003 and was higher (20.1±0.5 ‰) in 2004. Averaged Δ of *Q. serrata,* which were always lower than those of *Carpinus laxiflora* (red-leaved hornbeam), also were higher in 2004 (21.8±0.9 ‰) than that in 2003(20.7±0.3 ‰). WUE (Water Use Efficiency) of *Q. serrata* from carbon isotope discrimination ranged from 7 to 17mmol/mol and that of *C. laxiflora* ranged from 6 to 14mmol/mol during growing season in 2003. In 2004, it was impossible for WUE to be calculated due to loss of vapor pressure deficit. The nitrogen concentration was consistently lower in 2004. It is unlikely that there has been a significant change in nutrient supply/availability in 2003 and 2004. Diameter at breast height (DBH) measurements indicated that the growth rates of *C. laxiflora* and *C. cordata* in 2004 were consistently lower than those in 2003 ($P < 0.05$), while the growth rates of *Q. serrata* showed no significant difference. When the raw MODIS *GPP* image was utilized, the *GPP* in 2003 was 1027 g Cm^{-2} which was comparable to 1019 g Cm^{-2} in 2004. When these bad data were excluded, the mean *GPP* in 2004 was smaller than in 2003 by ~5%. Micrometeorological, chamber, biometric and isotopic measurements represent widely different temporal and spatial scales and measures but seemed to indicate a consistent ecosystem trait for Gwangneung forest during 2003 and 2004. Ecosystem processes occur at diverse temporal and spatial scales and therefore, single observation with limited scales often induces incomplete understanding. It is clear that the mutually consistent and complementary nature of interdisciplinary approaches presented above would provide greater advantages in studies for the ecosystem carbon and water exchanges in heterogeneous and complex landscapes.

This study is supported by "The Eco-Technopia 21 Project" from the Ministry of Environment, Korea and by a grant (Code: 1-8-2) from Sustainable Water Resources Research Center of 21st Century Frontier Research Program.

P21

MEASUREMENT OF CO_2 EXCHANGES IN A PEANUT FIELD: RESPONSES TO WATER STRESS

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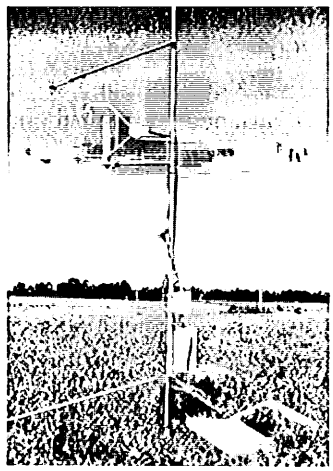
Peanut (*Arachis hypogaea* L.) is susceptible to drought stress of different duration and intensities for some period of the growing season and so plant water stress is one of the most critical abiotic factors limiting peanut yield. As climate change and land use cover change progress rapidly especially in Asia, water stress becomes a main concern of farmers even though it is grown in regions with abundant rainfall or irrigation. It is also important to decide how to distribute water to agricultural and urban areas. For meeting such demands, it is necessary to understand the peanut's response to water stress in relation to microclimates. In particular, autotrophic and heterotrophic respirations react differently to changes in environmental conditions. It is, therefore, crucial to get more insight into the response of both components of soil respiration (autotrophic and heterotrophic) to water stress. This study examines the role of ecosystem respiration rate and NEE (Net Ecosystem Exchange) and theirs relationships with environmental stress.



During crop year 2005, micrometeorological measurements were carried out over a non-irrigated peanut field near Vienna, Georgia. The fluxes of CO_2 and H_2O vapor were measured by the eddy-covariance technique. Environmental parameters such as wind direction and speed, air temperature and humidity, solar and net radiation, soil temperature, soil moisture, soil heat flux, and rain were also monitored. For separating soil respiration into autotrophic and heterotrophic respiration, we added the CO_2 gradient method and the root-exclusion method in 2006. Preliminary results show that ecosystem respiration is sensitive to air temperature. We also found that ecosystem respiration was a well-behaved function of soil moisture throughout the plant's life cycle.

P22

SEASONAL AND INTERANNUAL VARIATION IN EVAPOTRANSPIRATION AND ENERGY BALANCE OVER A LARCH FOREST

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The energy and water exchanges between terrestrial ecosystems and the atmosphere are strongly affected by vegetation on the surface. A grasp of these exchanges over a larch forest is important to understand Asian forest ecosystem, because larch is widely distributed from tundra to temperate zone in Asia.

The study site, Tomakomai Flux Research Site in Hokkaido, Japan (42°44'N, 141°31'E), was located in a larch plantation at a distance of more than 10 km from human habitation. The stands were about 45 years old and covered over 100 ha. The topography was almost flat with very little undulation. The canopy height was approximately 16m above the surface. We had measured water vapor and heat fluxes for more than three years before a disaster by a typhoon in September 2004. In this study, we analyzed flux data from 2001 to 2003.

Water vapor and sensible heat fluxes were measured using an eddy covariance system mainly consisting of a three-dimensional sonic anemometer-thermometer (DA600-3TV, Kaijo Corp.) and an open-path IRGA (LI7500, Licor Inc.).This system was installed at 27m height on the 42m-high tower. Meteorological factors were also measured on the tower and forest floor.

Figure 1 shows the closure of energy balance to check the quality of flux measurement using the eddy covariance method. Eddy energy flux, which is the sum of sensible heat flux (H) and latent heat flux (lE), accounted for 93% of available energy, which is the sum of net radiation (R_n) and ground heat flux (G). There is no remarkable difference in this tendency among three study years.

Seasonal variation in H was almost similar among three study years (Fig. 2(a)), however, lE in the growing season in 2001 was less than those in 2002 and 2003 (Fig. 2(b)) by more than 25%. Table 1 shows cumulative H, lE, R_n, G and precipitation, and mean leaf area index (LAI) from May through October. There is no significant difference in net radiation between three years, however, the other energy fluxes in 2001 differed significantly from those in 2002 and 2003. LAI in 2001 was less than those in 2002 and 2003; the small LAI probably resulted in the small lE in 2001.

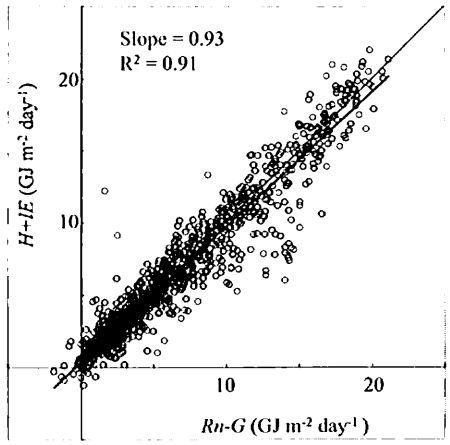

Fig. 1 The relationship between (H+lE) and (R_n -G)

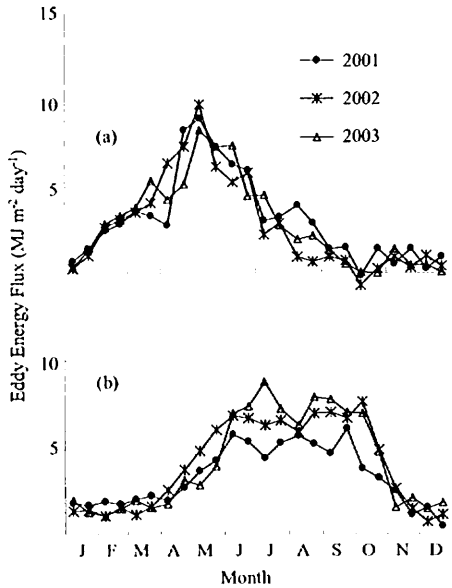

Fig. 2 Seasonal and interannual variation in H (a) and lE (b).

Table 1 Cumulative H, lE, R_n, G and precipitation, and mean LAI in the growing season from May to October.

		2001	2002	2003
Sensible Heat Flux	MJ m^{-2}	706.5	539.9	629.4
Latent Heat Flux	MJ m^{-2}	876.1	1167.1	1190.5
Net Radiation	MJ m^{-2}	1616.5	1655.5	1698.7
Ground Heat Flux	MJ m^{-2}	22.9	19.5	17.9
Precipitation	mm	929.5	729.3	773.3
LAI (mean)	m^2 m^{-2}	3.1	3.4	3.3

P23

ENERGY AND WATER FLUX OBSERVATION OF IRRIGATION PADDY FIELD IN PHITSANULOK, THAILAND

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The energy balance and actual evapotranspiration (water flux) of irrigation paddy field in Phitsanulok province, Thailand, was installed with the automatic weather station (AWS). The measurement of energy balance using Bowen ratio technique were collected during 2002 to 2003. The results showed that the net radiation(Rn), the latent heat flux (LE) and the sensible heat flux (H) were 411.3, 368.5 and 70.43 W/m^2. The results of evapotranspiration were found that in paddy field the average AET were 6.16 mm/day while the pan evaporation (Epan) was 4.32 mm/day respectively. In planting season the average AET were 493 and 525 mm/day, while Epan were 477 and 318 mm/day respectively.

P24

ENERGY BALANCE OF A TROPICAL PEAT SWAMP FOREST IN KALIMANTAN, INDONESIA

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Tropical peat swamp forests grow over tropical peatlands, which are widely distributed in flat lowlands in Southeast Asia. Since the 1970s, however, deforestation and drainage have progressed on an enormous scale because of growing demands for timber and farmland. In addition, El Niño and Southern Oscillation (ENSO) drought and its consequent fires are accelerating the forest devastation. The forest devastation alters energy balance and will influence regional climate. Thus, we have measured eddy energy fluxes above a tropical peat swamp forest left in a devastated peatland in Central Kalimantan, Indonesia since November 2001. Both in the rainy and dry seasons, latent heat flux (lE) considerably exceeded sensible heat flux (H). Net radiation (R_n) was mainly used by evapotranspiration (ET). An ENSO event occurred in 2002, and the consequent drought caused large-scale peatland fires in Central Kalimantan. A large amount of smoke emitted from the fires decreased R_n from mid-August through October. Bowen ratio (H / lE) decreased gradually from January through July in the range of 0.20–0.35. Although Bowen ratio decreased to a minimum of 0.15 in late September, it continued to increase during the late fire period and was high at 0.35–0.45 after the fires. ET accounted for 67 percent of precipitation (1856 mm) on an annual basis in 2002. Annual mean daily ET was 3.4 mm d^{-1}.

P25

PROFILING OF VERTICAL DISTRIBUTION OF CO_2 IN FOREST CANOPY

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The estimation of temporal variation of net ecosystem CO_2 exchange requires precise measurement of CO_2 flux. The eddy covariance (EC) method is common technique for measuring CO_2 flux above forest canopy. Recently, some measurement systems are commercially available as complete-kit forms and no special skill for installation and maintenance is needed for the EC measurements. Temporal change in CO_2 storage below the forest canopy is regarded as one of the flux components, but it cannot be observed by the EC measurements. Especially under the condition that air column is stable, measurements of the CO_2 storage is critical to evaluate ecosystem CO_2 exchange flux precisely. We developed a new measurement system for the CO_2 storage observation and installed it in the Fuji-Hokuroku Flux Observation site in Japan. Our new system measure CO_2 mixing ratio of air at 10 height levels in a sequential order with frequency of 2minites/1cycle. The flow-path and flow-rates of sample air are optimized to minimize cross contamination inside the system and to maximize the time-representativeness of each measurement. The gas analyzer was calibrated with four standard gases every 2 hours interval. The CO_2 mixing ratio of standard gases were determined to be the same scale as that used in baseline atmospheric CO_2 measurements. In this presentation, we introduce features of our newly developed system and results from measurements at the site.

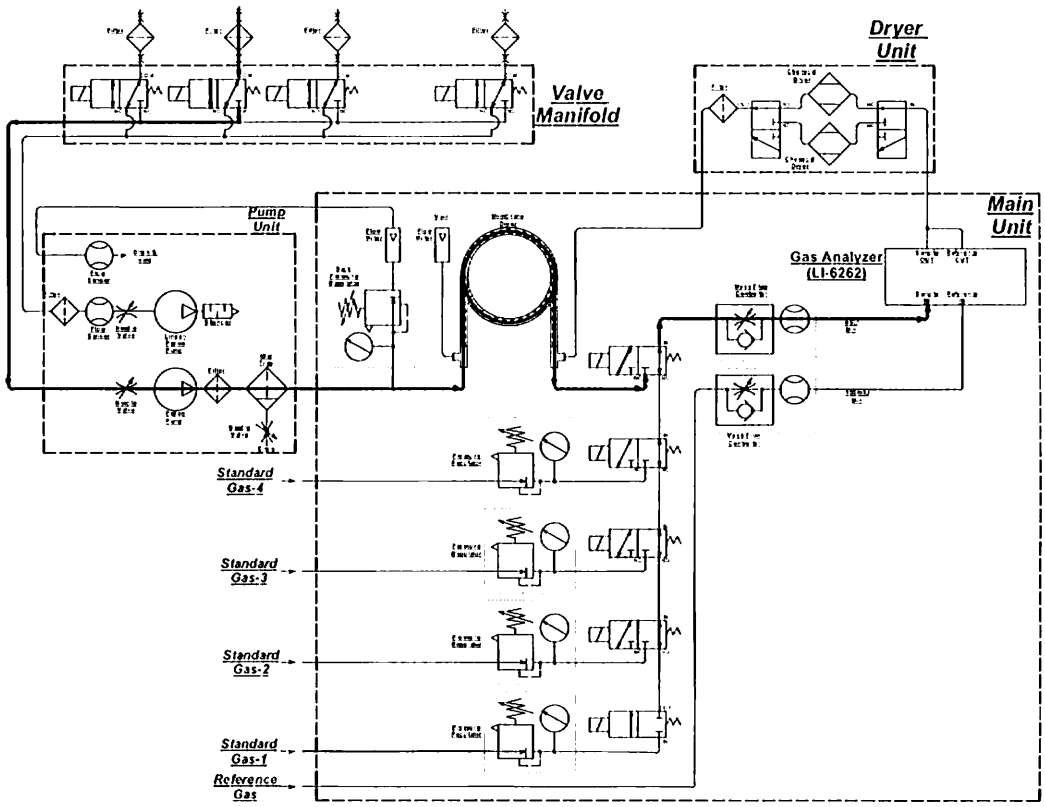

Figure 1. Schematic diagram of the CO2 profiling system installed in the Fuji-Hokuroku Flux Observation site.

P26

CO_2 CONCENTRATION PROFILE WITHIN A CANOPY OF A TROPICAL RAIN FOREST IN MALAYSIA AND A TEMPERATE CYPRESS FOREST IN JAPAN

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Globally, one of the most important interactions between terrestrial ecosystems and the atmosphere is the transfer of CO_2. Although the magnitude of the CO_2 exchange process varies from place to place, generally, CO_2 exchange between forest and the atmosphere is evaluated using the eddy covariance method. However, stored CO_2 in forest may not be negligible, especially in a tall canopy. Over a scale of 1 day or more, the change in CO_2 storage (S_c) is very small, but over a shorter timescale, S_c may be very large under certain conditions; therefore, it is necessary to measure S_c and evaluate its contribution to eddy flux (F_c). In the air space within a forest, the meteorological environment varies from the forest floor to the canopy top, and vertical profiling is critical in determining the process of CO_2 exchange. Thus, we conducted CO_2 concentration ($[CO_2]$) profile measurements continuously in a tropical rain forest and a temperate cypress forest. We then examined the daily vertical transition of $[CO_2]$ phases, the contribution of S_c to F_c, and differences between the forests.

Site and Methods

The tropical rain forest site was located at the Pasoh Forest Reserve (PFR), Negeri Sembilan, in Peninsular Malaysia (2°58' N, 102°18' E). The core area (600 ha) of the reserve was covered by a primary lowland mixed dipterocarp forest, which consisted of various species of *Shorea* and *Dipterocarpus*. The continuous canopy height was approximately 35 m, although some emergent trees exceeded 45 m. The total leaf area index (LAI) estimated from tree diameter observations was 6.52 (Niiyama, unpublished data). The annual mean air temperature was 26.6°C and the annual precipitation was 1630 mm during 2004/2005.

The temperate cypress forest site was located at the Kiryu Experimental Watershed (KEW) in Shiga Prefecture, Japan (34°58' N, 136°00' E). The site was mainly covered by *Chamaecyparis obtusa* Sieb. et Zucc., an evergreen conifer. The canopy height was approximately 18 m and the LAI ranged from 4.5 to 5.5. The annual mean air temperature was 12.9°C and the annual mean precipitation was 1639 mm from 2003 to 2005.

We measured wind speed and $[CO_2]$ at 10 Hz using a three-dimensional sonic anemo-thermometer and an open-path infrared gas analyzer (IRGA) at 54 m in the PFR and 28.5 m in the KEW and calculated F_c using the eddy covariance method. The reference frame of the covariances was rotated for every 30-min flux measurement to align the flux perpendicular to the mean streamline. The Webb–Pearman–Leuning (WPL) correction was applied for the effect of air density fluctuations. $[CO_2]$ profile measurements were conducted at several heights at both sites. Air samples for $[CO_2]$ measurements were drawn continuously from each inlet at ten levels in the PFR and five levels in the KEW to a closed-path IRGA through a polyethylene tube. The IRGA was located in an observation house on the forest floor. The IRGA was automatically calibrated daily using zero concentration gas (N_2). Switching between canopy heights was controlled by a control port module and a series of solenoid valves. The $[CO_2]$ at each height was determined every 30 min. These measurements were performed intermittently from September 2004 to November 2005 in the PFR and from March 2006 to September 2006 in the KEW.

Results and Discussion

At both sites, the daytime $[CO_2]$ was lower than that at night because of photosynthetic CO_2 uptake in the daytime and plant and soil respiratory CO_2 efflux and its accumulation at night. The soil surface $[CO_2]$ was always higher than that at any canopy level. At the KEW, S_c was largest in summer due to high soil respiration and plant assimilation. In contrast, obvious seasonality was not observed at the PFR. The diurnal fluctuation in the $[CO_2]$ at each height was larger in the PFR than in the KEW, indicating that the S_c at the PFR was larger. Indeed, the negative peaks of S_c were -12.7 μmol m^{-2} s^{-1} (78% of the negative peak of F_c, overall average) for the PFR and -2.9 μmol m^{-2} s^{-1} (16% of the negative peak of F_c, July average) for the KEW. The tall canopy and large LAI in the PFR may have caused this difference.

P27

FLUX DATA QUALITY CONTROL OF TAK FLUX MEASUREMENT STATION

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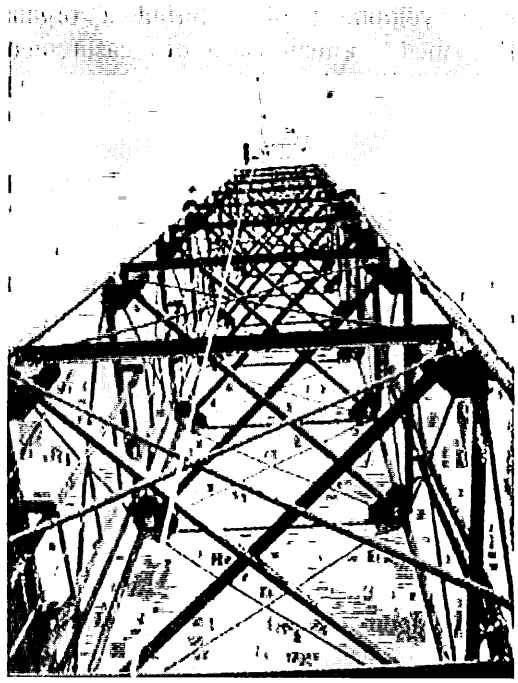
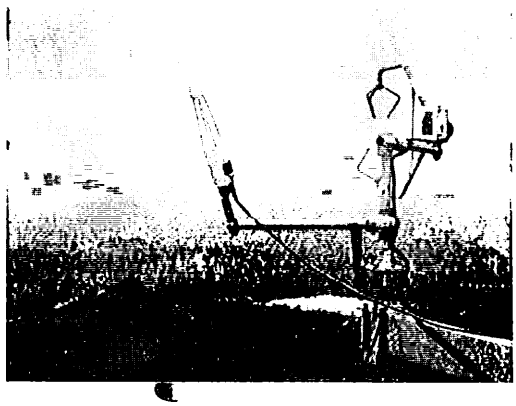
The experimental site (latitude: 16°56'N, longitude: 99°25'E), named Tak Flux Measurement Station (TFMS), is located about 20 km east of Tak and 50 km west of Sukhothai in the northwest part of Thailand. The TFMS is essentially a flat area of about 100 km^2 and 130 m higher than sea level. The fetch is more than 10 km with gently undulating hills with about 20 m differences in height. The climate of the experimental area is divided into wet and dry seasons as a part of the Southeast Asia Monsoon region. The onsets of the wet and dry seasons are in May and October, and the mean temperatures of each season are about 27°C and 31°C, respectively. The total annual precipitation is about 1200 mm.



The zonobiome of TFMS is the humido-arid tropical summer-rain region with deciduous forests by Walter classification (1994). Vegetation type is a mixed wet-deciduous forest with trees 20-25 m tall (e.g., *Tectona*, *Shorea* and *Dipterocarpus*) (Ruangpanit, 1995) and a sparse covering of grass with about 4.0 leaf area index. However a secondary forest matures on the fallow patches within about 10-20 years, due to exploitation by the population for shifting cultivation (Ogawa et al., 1971). According to our recent survey, the vegetation consists of 60% 10-15 m tall deciduous trees with 3-5 LAI, and 40% agricultural area cultivating rice, corn et. al.

The eddy covariance technique to measure the sensible and latent heat, and the carbon dioxide (CO_2) fluxes is used at the TFMS, Thailand. In applying the technique, two sets of instruments, consisting of three dimensional sonic anemometers (CSAT3, Campbell Scientific, Inc.) to measure wind velocity fluctuation and an open path CO_2 / H_2O gas analyzer (LI7500, LI-COR, Inc.) to measure vapor pressure and CO_2 fluctuation. They are mounted at the end of booms located at 30 m and 100 m levels attached to a 120 m climbing tower. The boom is able to fold for sensor maintenance and extends 2 m beyond obstacles. The length is 2 times longer than lateral dimension of tower to minimize wind flow distortion. Leveling of CSAT3 is carried out before the boom is opened and LI7500 is tilted 20 degrees to the north to prevent a radiation effect.



In terms of data quality control, several reports are available for assessment of high quality data (Vickers and Mahrt, 1996; Foken and Wichura, 1996; Falge et al., 2001; Lee et. al., 2004). It is important that those methods are applied to data processing in order to determine heat, energy and CO_2 fluxes using the eddy covariance technique. In this presentation, the methodical characteristics and experimental results of data quality control at TFMS from 2002 to 2006 are discussed in this presentation.

P28

SPATIAL AVERAGING EFFECT ON FLUX MEASUREMENT BY A SCINTILLOMETER APPLIED ONTO A FOREST CANOPY

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Development of a turbulent organized structure (TOS) is described as a main cause of measurement error in cases where the turbulent flux above a forest canopy is measured at a single tower. It is presumed that spatially averaged flux cannot be obtained solely from the temporal averaging of the eddy-covariance term because of the development of local vertical advection is caused by the TOS. We used two sets of eddy-covariance (EC) systems during May--November 2005 at 86-m intervals in a mixed deciduous forest (dominant species is Japanese mountain birch) of 18 m height with 28-m towers. Results showed apparent spatial variation of the turbulent flux between two towers of separated by 86 m; the energy imbalance of flux measurements increased concomitant with the increase of spatial variation of turbulent flux. The above-mentioned presumption was supported experimentally.
A mobile elevated working platform was used as an additional tower to establish a double orthogonal measurement path of the displaced-beam small aperture scintillometer (DBSAS). The averaged energy imbalance of heat flux measured using the two EC changed according to the difference of averaged dissipation rates between the DBSAS and the EC. Positive correlation between the dissipation rate of temperature fluctuations and the source area was apparent from simultaneous observations of orthogonal DBSAS. Although limited to measurements of the dissipation rate of temperature fluctuations, the spatial averaging effect of DBSAS was confirmed.

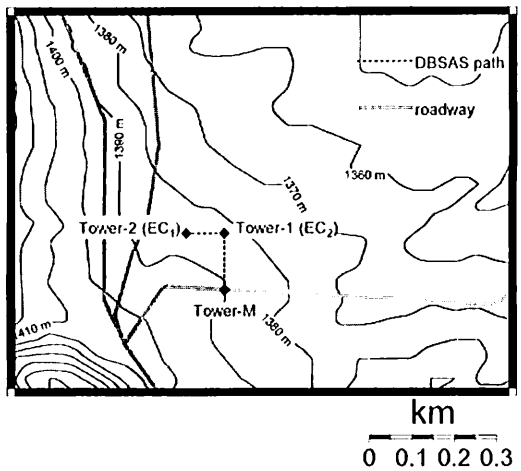

Fig 1. An overview of the experimental site and the tower arrangement for simultaneous measurements of DBSAS and EC

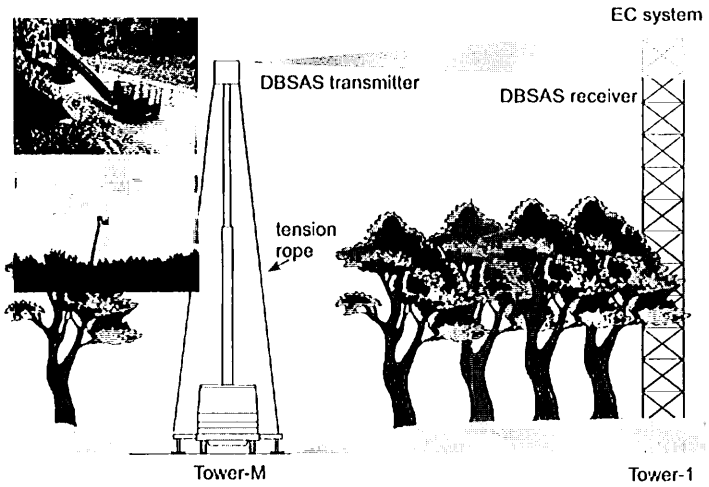

Fig 2. Mobile elevated work platform as an additional tower for the DBSAS

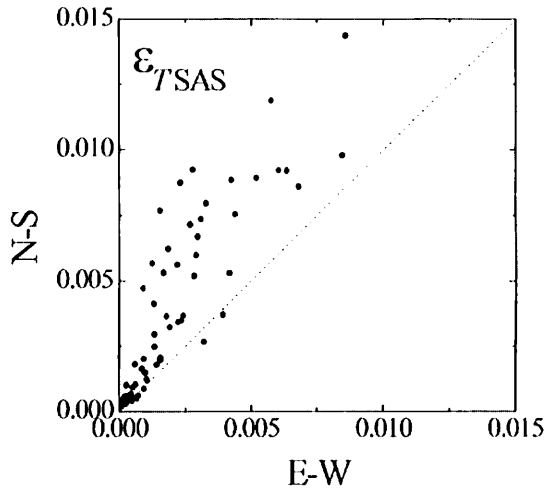

Fig 3. Comparison of the dissipation rate of temperature fluctuations between orthogonal paths of DBSAS

P29

EFFECT OF CORRECTION OF SONIC ANEMOMETER ANGLE OF ATTACK ERRORS ON EDDY FLUXES OVER BOREAL AND COOL TEMPERATE FORESTS

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From a previous study, ultrasonic anemometers have been shown to suffer errors depending on the angle of attack α (°), which is the angle between the wind vector and the horizontal (Gash and Dolman, 2003; van der Molen *et al.*, 2004). Building on the previous work of van der Molen *et al.* (2004), we propose an improved method of correcting for the angle of attack error resulting from the imperfect (co)sine response of ultrasonic anemometers which gives a closer representation of their wind tunnel calibration data for R2- and R3-type Solent ultrasonic anemometers (Gill Instruments, Lymington, UK) (Nakai *et al.*, 2006).

This correction method was applied to field data from four forests: a larch forest (YL) and a pine forest (YP) in Spasskaya Pad, near Yakutsk, Russia (boreal forests), a birch forest (MB) and a conifer-broadleaf-mixed forest (MM) in Moshiri , Hokkaido, Japan (cool-temperate forests). R3-50 Solent ultrasonic anemometers (Gill Instruments) and LI-7500 open path infra-red gas analyzers (LI-COR, Lincoln, USA) were used there.

The effect of the correction on the eddy fluxes was evaluated by linear regression through the origin using summer data (JJA) of 2004 (YL, YP) and 2005 (MB, MM). Figure 1 shows the increments in eddy fluxes (sensible heat flux, H, latent heat flux, lE and CO_2 flux, F_c) against $(z - d) / z_0$ (where z is measurement height, d is zero-plane displacement and z_0 is roughness length). The increments depend on $(z - d) / z_0$ and are larger over rough forest than over smooth forest, as would be expected from the analysis of Gash and Dolman (2003). For the MB site, however, the increments were larger than for the YL and YP site despite a larger $(z - d) / z_0$. MB site is located near a mountain ridge and has an inclination to the west (about 4°), and hence this slope might affected these relatively large increments.

Figure 2 shows the comparison of uncorrected and corrected accumulative net carbon fluxes at the MB site in 2005. Annual net carbon uptake was increased from −4.26 to −4.67 (tC ha^{-1}) due to this correction. This increment of 9.6% is larger than the increment on 30 minutes' data evaluated by the linear regression using whole data (7.9%), daytime (8.1%) and nighttime data (5.1%). It seems the smaller effect on uptake flux (nighttime) compared with that on downward flux (daytime) has a positive effect on the accumulated annual carbon flux, and hence the effect of the correction on annual flux was larger than that on 30 minutes' data.

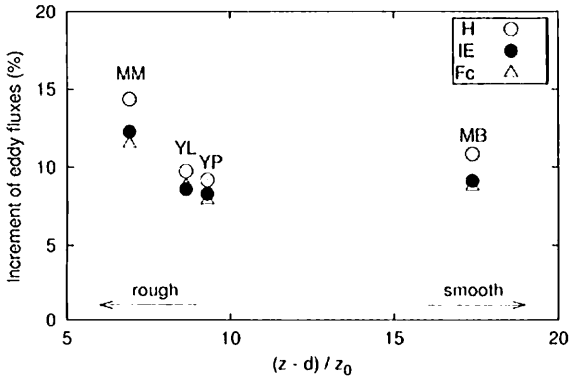

Fig 1. Plot of increments of eddy fluxes by correction against $(z - d) / z_0$.

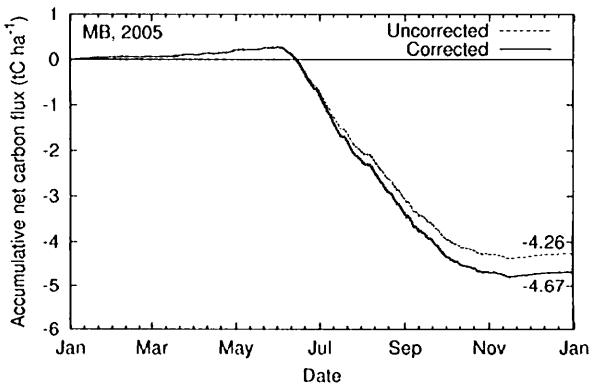

Fig 2. Comparison of uncorrected and corrected accumulative net carbon fluxes in MB (2005).

P30

LOCAL TEMPERATURE FLUCTUATIONS IN THE VICINITY OF AN OPEN-PATH GAS ANALYZER

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Introduction The WPL correction (Webb et al., 1980) postulates that all the variables involved in the correction are measured at the same point. In the strict sense, however, this is rarely satisfied in practical field measurements because the covariances in the WPL correction are usually measured with the separate two instruments, a sonic anemometer for sensible heat and an open-path gas analyzer for gas densities. Several studies recently published have discussed the prerequisite in association with unrealistic CO_2 uptake observed in dormant season with open-path eddy covariance (Burba et al., 2006; Ono et al., *submitted*). Ono et al. (*submitted*) found that unrealistic CO_2 uptake resulted from an artifact of open-path eddy covariance comparing with the closed-path eddy covariance and chamber methods, and then concluded that the WPL correction with the two instruments was not applicable to their measurements in some cases. Burba et al. (2006) indicated that the WPL correction could fail due to heat from the surface of an open-path gas analyzer and suggested a practical procedure to correct it. However, no studies have directly demonstrated that sensible heat fluxes measured with a sonic anemometer differ from those at the optical path of a colocated open-path gas analyzer when CO_2 uptake is apparent. We have challenged this since 2004 at a paddy field in Japan, and obtained substantial results from our recent experiment, which are presented in this study.

Method An ordinary instrumentation was employed for eddy covariance: a 3-D sonic anemometer-thermometer (CSAT3; Campbell Scientific, USA), an open-path infrared gas analyzer (LI-7500; LI-COR, USA), a closed-path infrared gas analyzer (LI-7000; LI-COR, USA). All digital singals from those instruments, including diagnostic data, were sampled at 20 Hz and stored in a data logger (CR5000; Campbell Scientific, USA). Fine-wire K-type thermocouples with a diameter of 0.025 mm (ANBE SMT, Japan) were placed near the center of the sonic path and at 3 different points in the optical path of the open-path gas analyzer. Signals from the thermocouples were also recorded with the logger at 20 Hz. Surface temperature of the open-path gas analyzer and other micrometeorological variables were also measured. We carried out the measurement at a paddy (36.05°N, 140.03°E) in March and April of 2006 and obtaied 18-day data. During the period there were few active plants in and around the paddy, which implied that only soil respiration could contribute to atmospheric CO_2 flux. All statistics in this study were calculated every 600 s by block averaging.

Results For the sake of the subsequent analyses we compared temperature fluxes derived from the sonic anemometer with those from the colocated fine-wire thermocouple. After the water-vapor correction, those temperature fluxes did not differ except under windy conditions. With mean horizontal wind velocity over 10 m s^{-1}, the sonic anemometer overestimated sensible heat flux by 20 W m^{-2} on average, but did not mean air temperature. The difference in sensible heat flux was equivalent to approximate 1 μmol m^{-2} s^{-1} in the WPL correction. Consequently data that were collected under windy conditions, $\geqslant$ 8 m s^{-1}, were excluded from the present analyses. Temperature fluctuations measured by the 4 fine-wire thermocouples were not different in phase and amplitude except in calm and clear sky daytime, when temperature fluctuations at the lower part of the optical path of the open-path gas analyzer were greatly increased and sometimes exceeded those at the sonic path by up to 180 W m^{-2}. Other parts such as the middle and upper spaces of the optical path, however, did not show such increased fluctuations. The local heat transports at the lower part of the optical path were also obvious in 20-Hz time series data. The data showed that updrafts often transported heat at the lower part, sometimes at the middle part too, of the optical path, but not at the sonic path. CO_2 densities as measured with the open-path gas analyzer decreased in warm updrafts. These results indicated that local temperature fluctiations in the vicinity of the optical path could influence the WPL correction. Applying the in situ measurements of temperature fluctuation did not always improved the WPL correction, but rather often led overestimation of the WPL correction.

P31

LARGE-SCALE TRANSPORT OF SENSIBLE HEAT AND WATER VAPOR TRANSPORT OVER A SHORT CANOPY

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The issue of the flux components at the largest scales has remained unresolved: indeed, the questions to what extent the transport by larger scale motions should be included in the flux calculation, and what is the relevant physical mechanism are left unanswered so far. This study examines the nature of vertical transport of sensible heat and water vapor density due to mesoscale motions and how they are observed with surface eddy covariance systems. For this purpose, turbulence data measured above a flat and irrigated rice paddy field in Tsukuba, Japan (36°05'N, 140°03'E) under unstable conditions were analyzed. It was shown that larger scale component in the measured time series represents mesoscale motions. Wavelet cospectra of the scalar fluxes revealed the presence of vertical transport at horizontal scales larger than the cospectral gap. A time series and the eddy covariance flux were decomposed into a turbulence and a mesoscale component using the identified cospectral gap. The mesoscale transport component of sensible heat and water vapor were found to be related to the wind direction, and, therefore, characteristic of the upwind surface conditions at this scale. With southeasterly wind, it was characterized by the moister air advection due to greater surface evaporation at the upwind surface conditions. With non-southeasterly wind, in contrast, it was characterized by the drier air advection associated with relatively drier urbanized area. In addition to these moist or dry air advection, the remarkable difference of surface temperatures between paddy field and external area may induce mesoscale circulations. On the other hand, the turbulence flux component exhibits universal attributes resulting from the local surface characteristics.

P32

COMPARISON OF THE TURBULENCE CHARACTERISTICS OF THE ATMOSPHERIC SURFACE LAYER OVER A RICE PADDY AS OBSERVED BY A TETHERSONDE SYSTEM AND BY AN EDDY COVARIANCE SYSTEM

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The turbulence characteristics of the atmospheric surface layer (ASL) over a rice paddy were measured using both tethersonde and eddy covariance (EC) systems. Comparisons of the friction velocities and Bowen Ratios estimated from the observations by both systems show correlation coefficients to be > 0.7. Their discrepancy can be associated with the discrepancy between their fingerprint areas. Compared to the tethersonde measurement, no significant underestimation for the total turbulent heat flux observed by the EC system can be identified. The aerodynamic roughness estimated from both tethersonde and EC data is determined to be 0.02-0.03 m for wind coming from a homogeneous rice paddy and > 0.07 m from a rice paddy interspersed with buildings. During daylight hours, the height ranges of the ASL were measured, ranging from a few meters to 25 m agl over the homogeneous rice paddy, and 14 m – 42 m over the rice paddy interspersed with buildings. However, the ratio between the zero-plane displacement height and aerodynamic roughness was observed as > 10, higher than the commonly suggested ratio. Finally, an empirical equation for determining aerodynamic roughness over heterogeneous land cover is examined.

P33

DEVELOPMENT OF A FLUX TOWER FOR LONG-TERM FLUX MEASUREMENT OF AIR POLLUTANTS IN AN URBAN AREA

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Current air quality stations only measure concentrations of air pollutants. Nonetheless, the concentrations are functions of meteorological conditions and emission rates. There is a need to measure the long-term trend of emission rates directly for evaluating air quality management strategies. This study presents our effort to build such a flux tower. The profile method is used in this study. That is, the vertical mass flux F of a pollutant (kg m^{-2} s^{-1}) is determined according to the mass transfer theory as: $F = -K_z(dc/dz)$, where Kz is vertical eddy diffusivity (m^2 s^{-1}) and $\partial C/\partial z$ is the concentration gradient.

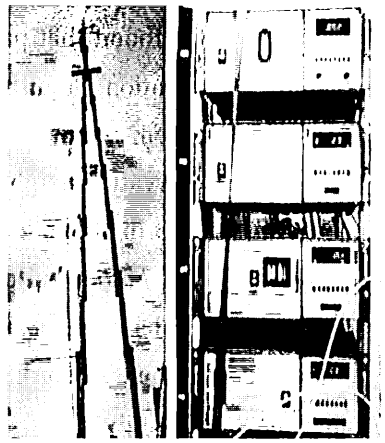

Fig 1.Urban flux town

Air pollutant concentrations are continuously observed at four heights at 32.5 m, 36.5 m, 40.5 m, and 46.5 m above ground level. They are measured on a tower (Fig 1) standing on the roof of a 7-floor building in the third largest city (Taichung City, 24°12' N, 120°67' E) in Taiwan. The vertical eddy diffusivity is determined according to the similarly theory for the atmospheric surface layer. Five pollutants including ozone, nitrogen monoxide, nitrogen dioxide, carbon monoxide and sulfur dioxide are measured at the 4 heights. In addition, eddy covariance system for measuring sensible heat flux, latent heat flux and CO2 is installed. During the test period from 25 March to 11 April 2006, it is found that the derived NO and NO2 fluxes were upward during the daytime and were almost zero during the night. This pattern can be compared with the emission inventory derived according to the traffic volume of the nearby road.

P34

SURFACE ENERGY CLOSURE OBSERVED AT VARIOUS HEIGHTS ON AN URBAN FLUX TOWER

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The energy imbalance has been observed at many flux towers. This study has found that parts of the reasons are due to the fact that the observation of turbulent heat fluxes by using the eddy covariance system is not at height within the atmospheric surface layer. Two observation heights were tested. One measured turbulent heat fluxes at 33 m above ground level on a tower (Fig 1) standing on the roof of a 7-floor building (24°12' N, 120°67' E) in the third largest city (Taichung City) in Taiwan. The other measured the fluxes at 50 m agl. According to a tethersonde ballon observation analysis, at the study site, the ASL is within 40 – 70 m agl. That is, obsevaition at 50 m agl was within the ASL, while the observation at 33 m agl was not.

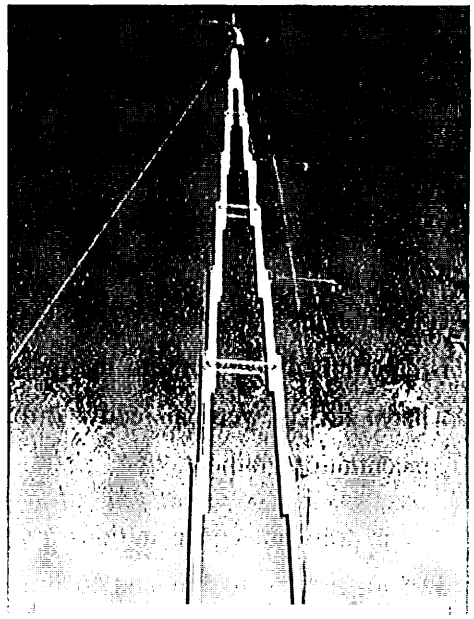

Fig 1. Flux tower

While measuring the turbulent heat fluxes at 33 m agl, it is found that the sum of the turbulent fluxes was 21 % lower than the available surface heat flux. In addition, it is found that the mean vertical velocity was about -0.06 m s^{-1} for northern wind, which was likely caused by the building wakes. On the contrary, while measuring the turbulent heat fluxes at 50 m agl., the sum of the fluxes was only 4 % lower than the available surface heat flux. In addition, the mean vertical velocity was to 0 at 0.01 m s^{-1} for northern wind. Note that corrections were made to reduce the energy gap, including coordinate system rotation, WPL correction, urban albedo correction, advected term correction, and long-wave radiational cooling term correction. The average urban albedo is determined to be 0.20 estimated within the radius of 1.4 km from the tower site (Fig 2).

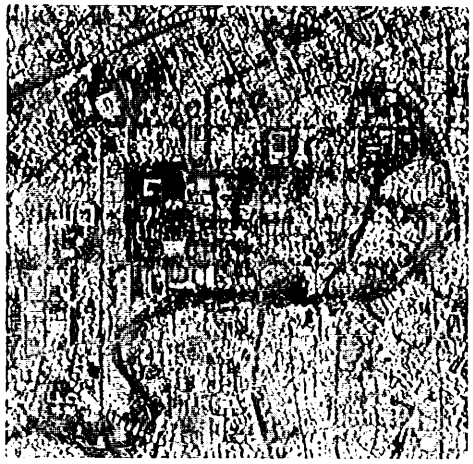

Fig 2. Landuse within the footprint area of the study site

P35

TIME SERIES ANALYSIS OF SOIL MOISTURE AT A STEEP HILLSLOPE

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Understanding the hydrological processes at a hillslope scale can be achieved through intensive in situ monitoring of an intermediate hydrologic variable, soil moisture, during rainfall events. A soil monitoring system for a hillslope with steep relief and shallow soil depth was installed to efficiently represent the spatial and temporal features of soil moisture on the conjunction of the terrain attributes. The soil moisture responses to sequential rainfall events were obtained as multiple time series. Time series analysis provides a systematic method of evaluating the stochastic characteristics of hydrologic variable. A derivation of the soil moisture transfer mechanism can be used as the physical basis of soil moisture time series analysis. After recording the soil moisture response patterns for a few consecutive rainfall events, a time series modeling procedure was applied to configure the characteristics of soil moisture.

The stochastic structures of soil moisture time series were explored in conjunction with topographic attributes such as the topographic wetness index, contributing upslope area and pathway distance from the outlet. Even though the variations in soil moisture did not have a significant linear or proportional relationship with the topographic attributes, the existence of potential threshold for formulation of time series models was found. The monitoring locations can be characterized from the final model structures of soil moisture in the context of topographic parameters. Distribution of the models on the hillside suggested that the distribution and existence of macropores can be an important component for explaining the soil moisture dynamics of a steep hillslope.

This study employed univariate models to analyze soil moisture time series. Introduction of more elaborated analysis method such as transfer function, prewhitening causality analysis can provide more comprehensive insight but will also cost more and easily suffer from the uncertainty effective rainfall input in the scale of the study area. This research was performed using soil moisture during the late autumn season. Analysis of this restricted soil moisture data may need to be further generalized. Further analysis of the extended monitoring of soil moisture and more elaborate time series techniques are future research issues for configuring complete soil moisture dynamics.

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P36

ESTIMATE OF PRODUCTIVITY IN ECOSYSTEM OF THE BROADLEAVED-KOREAN PINE MIXED FOREST IN CHANGBAI MOUNTAIN

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Forest is an important type of natural vegetation. Forests are considered to be the terrestrial ecosystems that assimilate the largest amount of CO_2 and store it for a relatively long time. Forest accounts for about 70% of the total carbon storage in terrestrial ecosystems. Recently, the eddy-covariance technique and chamber method are used in estimation of ecosystem carbon exchange.

Methods:

Study site

The study site is located in Changbai Mountain Natural Reserve (42°24′0 9″N, 128°05′45″E) at an altitude of 738 m. The site is characterized as a mountain climate.

we used The NEE obtained by the eddy covariance method was compared with those observed with chamber measurements.

Different component and whole system CO_2 flux measurements

NEE were measured at 40 m with a tri-axial sonic anemometer (model CAST3, Campbell, USA) and a fast response open-path CO_2/H_2O infrared gas analyzer (Li7500, Li-Cor Inc., Lincoln, USA). Different component CO_2 fluxes were obtained by chamber techniques

Estimate of productivity of forest ecosystem

Net carbon exchange of ecosystem (NEE) refers to net primary production subtracts loss of carbon by heterotrophic respiration (R_h). An empirical equation was used to calculate the aboveground biomass of each tree species. Net increment of forest biomass was the sum of stem, branch, root and foliage biomass. The former year DBH value was calculated according to the growth ring data, and then calculated the former annual biomass using the empirical equation. The net increment of biomass was the difference of the two years.

Results

The amount of carbon accumulated underground in broad-leaved Korean pine mixed forest ecosystem was soil respiration subtracted falling leaves, and the value was 841.98 gC· m^{-2}· a $^{-1}$ (Table 1). Assume plant roots consumed 50% of the carbon accumulated underground during growth, then the root respiration CO_2 efflux was 424.2 gC· m^{-2}· a $^{-1}$ which contributed to 44% of soil respiration, and accounted for 31% of ecosystem CO_2 efflux.

The gross primary production (GPP) of the forest was the total sum of system photosynthesis (1612.74 gC· m^{-2}· a $^{-1}$). Trees, shrubs and herbage annual primary production accounted for 89.7%, 3.5% and 6.8% of the gross primary production of the mixed broad-leaved Korean pine forest. The sum of system autotrophic respiration (foliage respiration, branch respiration and root respiration) was 843.4 gC· m^{-2}· a $^{-1}$. The amount of annual accumulation of carbon underground accounted for 0.52 of gross primary production, and the ratio of soil respiration to gross primary production was 0.60. Annual carbon accumulation of the needle and broad-leaved Korean pine forest ecosystem was 856.2 gC· m^{-2}· a $^{-1}$and the NEE was 229.51 gC· m^{-2}· a $^{-1}$.

Table 1 Different component biomass (gC·m^{-2}), respiration gC·m^{-2}) and net primary production (NPP, gC·m^{-2}·a^{-1} in the broad-leaved Korean pine forest ecosystem

component	/gC· m^{-2}
biomass:	
foliage biomass	417
branch biomass	15696
gross biomass aboveground	16113
annual fallen leaves	122
respiration:	
annual leaf respiration	210.41
annual stem respiration	208.84
annual soil respiration	963.98
annual ecosystem respiration	1383.23
growth:	
annual leaf growth	225.99
annual aboveground growth	513.32
annual net primary production ANPP	541.31
annual underground carbon accumulation (soil respiration and fallen leaves)	841.98
annual underground carbon accumulation: GPP	0.52
annual underground carbon accumulation: soil respiration	0.87
underground NPP: NPP	0.33
NPP:GPP	0.48
NEE	229.51
NPP	769.3

P37

CARBON CYCLING IN THE TROPICAL DRY EVERGREEN AND DECIDUOUS FORESTS IN THAILAND

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A study on carbon cycling of tropical forests in Thailand was aimed at determining temporary changes in carbon balance of two contrasting terrestrial forest ecosystems. A dry evergreen forest at the Sakaerat Environmental Research Station, Nakhon Ratchasima province, and a mixed deciduous forest with bamboos at the Maeklong Watershed Research Station, Kanchanaburi province were studied during May 2003 – April 2005. For each study site, a one ha sampling plot was established to determine forest structure and carbon stored in biomass and soils as well as forest CO_2 exchange in terms of plant photosynthesis and emission through autotrophic and soil respiration.

The two studied forests indicated distinctive canopy structure and species composition. The dry evergreen forest was dominated mainly by *Hopea ferrea* with the importance value index (IVI) of 101, while the most important tree species of the mixed deciduous forest were *Pterocarpus macrocarpus*, *Xylia xylocarpa* and *Schleichera oleosa* respectively, as well as two bamboo species, *Bambusa tulda* and *Gigantochloa albaciliata*. The former also had higher tree density and basal area, thereby gaining greater biomass production and carbon stored in biomass. The result on annual carbon changes showed that, compared with the mixed deciduous forest, the dry evergreen forest gained remarkably higher net primary production (NPP) due to greater biomass increment even less litter production. Likewise, the dry evergreen forest sequestered considerably greater CO_2 through plant photosynthesis and released higher CO_2 to the atmosphere through autotrophic respiration than did the mixed deciduous forest. Expectedly, CO_2 emitted from soil surface in both studied forests accounted for almost 50% of the total CO_2 emission. Overall, the dry evergreen forest showed higher potential as carbon sinks compared to the mixed deciduous forest. Further developments of some measurement techniques of ecosystem photosynthesis and respiration are, therefore, required to provide useful insights into CO_2 dynamics in these terrestrial forest ecosystems.

Keywords carbon cycling, gross primary production, net primary production, dry evergreen forest, mixed deciduous forest

P38

OBSERVATION-BASED HYDROMETEOROLOGICAL STUDIES AT TROPICAL MONSOON FORESTS IN THAILAND

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This study summarizes forest types of tropical monsoon forests in Thailand, and reviews published hydro-meteorological studies conducted at each forest type with emphases on our new findings derived from two forest sites in the region. As a result of summarizing current status of knowledge, this paper finds that fundamental hydro-meteorological aspects, i.e. seasonal variation in energy partitioning during a year with normal climatic condition, at most of the forest types in the region has been already studied. Contrast in seasonality of evapotranspiration (ET) between the uplands and lowlands might be a noteworthy feature of hydro-meteorology in tropical monsoon forests in Thailand. As is often discussed in studies at Amazonian rain forests with defined dry period, accessibility of roots to deep soil layer is suggested to be an important factor supporting the elevated ET rate during the dry season. In addition, inter-annual variations both in rainfall and its seasonal distribution are significantly large in the region, leading to occasional severe droughts and irregular ecological rhythms of trees. Recent findings from our long-term observations imply that the variations in rainfall result in phenological and physiological responses of the two forest ecosystems. These responses may in turn affect the hydro-meteorology such as exchanges of energy, water, and carbon dioxide between the forest ecosystems and the atmosphere. Such effects of year-to-year variations in rainfall on the tropical monsoon forests have been poorly understood thus far. We, therefore, stress the necessity of further efforts to examine the ecological and hydro-meteorological responses of all tropical monsoon forests to the inter-annual variation in rainfall and its seasonality.

P39

DEFFIRENCES IN ENVIROMTENTAL RESPONSES OF CANOPY CONDUCTANCES BETWEEN UNDERSTORY VEGETATION AND MAIN CANOPY TREES IN A BOREAL FOREST

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Boreal forests have a unique feature compared with forests in other climate regions: monotonous vegetation, relatively sparse stand density of main canopy trees and thus, dense understory vegetation. Many previous papers indicated that the transpiration from the understory occupied 50% of total evapotranspiration. Therefore, we need to know how the transpiration from the understory responds to environmental conditions. We derived canopy conductance of the main canopy and the understory from water and heat fluxes observed above both of them, and revealed the differences between them.

Materials and Methods

We observed water and heat fluxes at a larch forest (60°14'18"N, 129°39'02"E) in Spasskaya Pad, Yakutsk city, Republic of Sakha, Russia. The main forest canopy is composed of larch (*Larix cajanderi*), and the forest floor was completely covered with cowberry (*Vaccinium vitisideae*). Air temperature (T_a), vapor pressure deficit (*VPD*) and photosynthetic photon flux density (*PPFD*) were measured at the top and the bottom of tower: measurements at the top ($_T$) and the bottom ($_B$) represent the conditions of the larch and the understory canopies, respectively. The latent and sensible heat fluxes at the top and the bottom were observed by the eddy covariance method. Canopy conductance (g_c) was calculated from the inverted Penman-Monteith equation. We obtained canopy conductance of the understory vegetation ($g_{c\text{-}B}$) and larch ($g_{c\text{-larch}}$): $g_{c\text{-}B}$ was calculated from actual evapotranspiration at the bottom of the tower (ET_B), and $g_{c\text{-larch}}$ was derived from the difference between ET_T and ET_B (*i.e.* $ET_{larch} = ET_T - ET_B$). Finally, to evaluate the responses of g_c to the environmental variables, a Jarvis- type g_c model was applied.

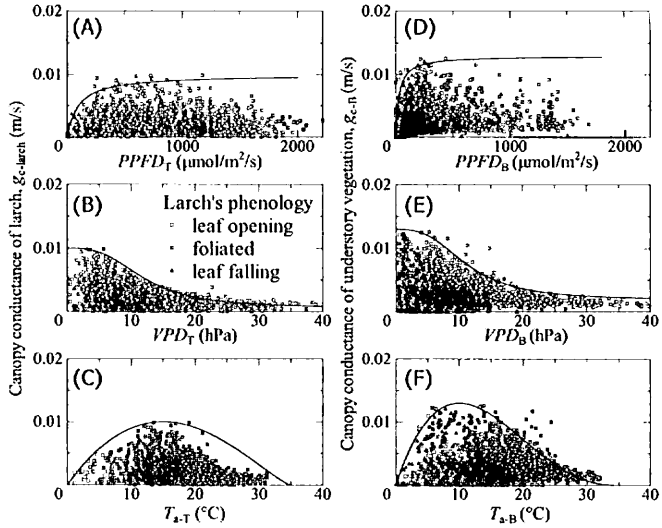

Fig. 1 Responses of canopy conductance to environmental factors.

Results and Discussion

Figure 1 shows responses of $g_{c\text{-larch}}$ and $g_{c\text{-}B}$ to environmental factors observed at each corresponding height. The maximum value of $g_{c\text{-larch}}$ was somewhat smaller than that of $g_{c\text{-}B}$. Although the response of $g_{c\text{-larch}}$ was relatively similar to that of $g_{c\text{-}B}$ (Figs. 1-B and E), their responses to *PPFD* and T_a were different (Figs. 1-A and D, C and F). Optimal temperature of $g_{c\text{-}B}$ was 10 °C, that is 5 °C smaller than that of $g_{c\text{-larch}}$ (Figs. 1-C and F), and $g_{c\text{-}B}$ increased with *PPFD* more rapidly than $g_{c\text{-larch}}$ (Figs. 1-A and D). These differences suggested that the understory vegetation photosynthesized efficiently during the relatively colder period, in which the larch's leaves defoliated and/or were budding, and were falling. However, the biomass of understory is much smaller than that of larch: the understory may consume inefficiently water than larch for photosynthesis during the foliate period? We will evaluate the water use efficiency of the larch and the understory in a future work.

P40

COMMON POTENTIAL RESPONSES OF CANOPY CONDUCTANCE TO ENVIRONMENTAL VARIABLES IN VARIOUS FORESTS IN THE FAR EAST REGION

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Canopy conductance (g_c) is important as a controlling factor for water, gas and heat exchange between vegetation and the atmosphere. We investigated g_c variations in five different forest types distributed from central to high northern latitudes in the Far East. We applied a Jarvis-type g_c model (Jarvis, 1976) to the data for the mature growing seasons of 2003, 2004 and 2005 and examined the response characteristics of g_c to environmental factors.

Materials and Methods

The research sites were five mature forests in the Far East region: two boreal larch and pine forests in eastern Siberia (sites L-YKS and P-YKS, respectively); two cool temperate birch and mixed forests in Hokkaido, Japan (B-HOK and M-HOK, respectively), and one warm temperate mixed forest in Aichi, Japan (M-AICHI). Micrometeorological observation towers were installed at each site to measure fluxes and meteorological variables. Water and energy fluxes were calculated using the eddy covariance technique. g_c was calculated using the Penman–Monteith equation (big-leaf model). The Jarvis-type g_c model (Jarvis, 1976) expresses g_c as a function of several environmental variables. We used photosynthetic photon flux density (Q), vapor pressure deficit (D), air temperature (T) and volumetric soil water content (W) as the environmental variables and evaluated the responses of g_c to these variables.

Results and Discussion

Figure 1 presents the responses of g_c to the environmental variables at each site and the lines of the functions in a model fitted for all site data. The responses of pooling g_c at all sites could be expressed as one lumped fitted line (model). It is interesting that the difference in maximum g_c among sites was well explained by the lumped fitted line of W. g_c estimated by the lumped model agreed well with the observed g_c at each site. Although it has been assumed that the behaviours of gas exchange properties in forests are site- or forest type-specific, we believe that the lumped model lines indicate the rough "potential" response curves of g_c to environments in mature forests in the northern Far East region, even if small differences exist among forests. If this concept is correct, it will be effective in spatial parameterisation of heat, water and gas exchange between vegetation and the atmosphere in the Far East region.

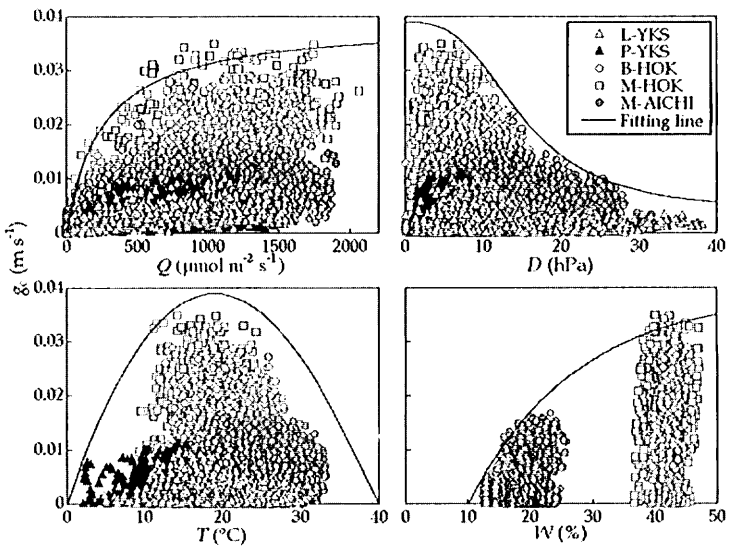

Fig. 1 Relationships between g_c and various environmental variables, and the fitted line for all data (the lumped model).

P41

CARBON AND OXYGEN ISOTOPE RATIOS OF TREE LEAVES GROWN IN DIFFERENT CLIMATES IN EAST ASIA

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Water-use efficiency and stomatal conductance are important indicators of leaf-scale control over CO_2 and H_2O exchange between trees and the atmosphere. Carbon isotope ratio ($\delta^{13}C$) of leaf organic matter is known to reflect water-use efficiency (Farquhar *et al.* 1989). Oxygen isotope ratio ($\delta^{18}O$) of leaf organic matter may also reflect leaf evaporative condition (Farquhar 1998). Therefore, $\delta^{13}C$ and $\delta^{18}O$ in tree leaves are expected as useful tools to know the response of leaf gas exchange to climate change (Barbour et al. 2000). However, the $\delta^{18}O$ model is still under development and has not been tested on various types of trees. This study presents the $\delta^{13}C$ and $\delta^{18}O$ in leaf organic matter of various trees grown in different climates in East Asia.

We collected sunlit leaves from current year shoots of dominant-trees in warm-temperate broad-leaved forest (Akou, Hyogo, Japan), warm-temperate coniferous forest (Kiryu, Shiga, Japan), cool-temperate deciduous broad-leaved forest (Tomakomai, Hokkaido, Japan), rainforest (Pasoh, Peninsular Malaysia), rainforest (Lambir, Borneo Malaysia)and desert (Mu-Us, Inner-Mongolia, China). The leaves were oven-dried at 70°C for 48 h, and finely ground. The $\delta^{13}C$ of the leaf samples was analyzed with a continuous-flow isotope-ratio mass spectrometer (Delta-S, Thermo Electron) following an elemental analyzer (EA-1500, Carlo Erba) at the Center for Ecological Research, Kyoto University. The $\delta^{18}O$ of the leaf samples were analyzed with a continuous-flow isotope-ratio mass spectrometer (Delta-plus-XP, Thermo Electron) following a pyrolysis furnace in a elemental analyzer (TCEA, Thermo Electron) at the Research Institute of Humanity and Nature.

A positive relationship was found between $\delta^{13}C$ and $\delta^{18}O$ in leaf organic matter (Fig 1). The tropical trees, which had low water-use efficiency and high stomatal conductance, tended to have lower $\delta^{13}C$ and $\delta^{18}O$. The semi-arid trees, which had high water-use efficiency and low stomatal conductance, tended to have higher $\delta^{13}C$ and $\delta^{18}O$. This suggests that $\delta^{13}C$ and $\delta^{18}O$ in leaf organic matter present the gas exchange trait and affected by water conditions.

Acknowledgment

We thank Drs. F. Hyodo, A. Rahim Nik, K. Yoshikawa, L.H. Wang and Y. Tanaka for field observation, and Drs. T. Yoshioka, A. Sugimoto, I. Tayasu and G. Farquhar for isotope analysis.

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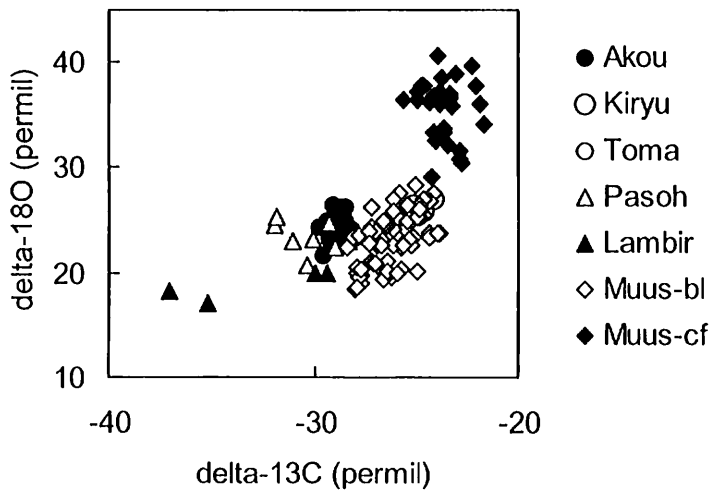

Fig 1. $\delta^{13}C$ and $\delta^{18}O$ in leaf organic matter of various trees grown in different climates.

P42

SIMULTANEOUS ISOTOPIC DETERMINATION OF CO_2 AND METHANE EXCHANGED BETWEEN THE PADDY AND THE ATMOSPHERE REVEALS MARKED DIFFERENCES IN GAS EXCHANGE PROCESSES BETWEEN FLOODED AND DRAINED CONDITIONS

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*A*t the ecosystem and global scales, the carbon isotopic compositions of CO_2 and methane exchanged between the biosphere and the atmosphere (δ_N and δ_M, respectively) have been used to partition net fluxes of CO_2 and methane into the source and sink terms. In comparison with other terrestrial ecosystems, rice paddies are unique because they provide the primary food source for over 50% of the world's population and act as major sources of global methane. In the present study, the importance of high-frequency simultaneous measurement of δ_N and δ_M was demonstrated in a Japanese rice paddy.

*W*e investigated short-term variations in δ_N and δ_M by combining stable isotopes and concentration measurements within and above the canopy, in conjugation with continuous aerodynamic flux measurements of CO_2 and methane on two representative days of flooded and drained conditions. For both CO_2 and methane, strong linear relationships were found between the measured isotopic compositions and the inverse of concentrations over the time spans of 2 hours to 1 day, which enabled us to examine diurnal variations of δ_N and δ_M solely form measured data. Both δ_N and δ_M showed large differences in magnitude and diurnal pattern from those obtained by the conventional isoflux approximation, in which δ_N or δ_M varies linearly with the period-averaged concentration measured above the canopy.

*U*nder flooded condition, δ_N varied between –25.8‰ and –20.2‰ and had lower values around noon, indicating that the assimilated CO_2 had more negative $\delta^{13}C$ values than the respired CO_2. After drainage, δ_N increased by about 2‰ on average and showed a more pronounced diurnal pattern, consistent with increased methane emissions and nighttime CO_2 fluxes. On the other hand, the diurnal pattern of δ_M under flooded conditions showed clear midday ^{13}C enrichment by about 8‰. This strong diurnal shift in δ_M is likely to be associated with a transpiration-induced bulk flow of methane and/or with an enhanced microbial oxidation of methane during the daytime. However, under drained conditions, δ_M showed the opposite diurnal pattern with lower values during the daytime and highly ^{13}C-enriched values at night. This strongly supports that floodwater drainage enhances methane oxidation but can bring about large emissions of less-oxidized methane through the soil surface in the daytime.

P43

ESTIMATING EVAPORATION FLUX IN THE HAN RIVER BASIN, KOREA, USING STABLE ISOTOPE TECHNIQUES

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Stable isotope composition of water (both liquid and vapor) is widely used to constrain water budget in various terrestrial settings. The advantage of isotope technique is in the fact that it enables a quantitative estimation of evaporation flux. In terms of $^{18}O/^{16}O$ and D/H ratios of water, evaporation imparts two different fractionation effects, i.e., equilibrium and kinetic. Both processes increase the isotopic ratios of water that was subjected to evaporation. Unlike the equilibrium fractionation effect occurring at 100% relative humidity, the kinetic effect (occurring at RH lower than 100%) arises due to the difference in diffusivity of isotopic species of water molecules and enriches water with the heavier oxygen isotopes (^{18}O) relative to the heavier hydrogen isotopes (Deuterium, ^{2}H). Rain water is a typical example of equilibrium isotope fractionation between water and vapor, which is represented by slopes of ~ 8 if the isotope data of water plotted in $\delta^{18}O - \delta D$ space (Meteoric Water Line, MWL). Kinetic fractionation effect is widely observed in most natural evaporation settings such as lakes and soils and results in isotope data of remaining water whose slopes are 4 ~ 6 in $\delta^{18}O - \delta D$ cross plot.

Based on this isotope fractionation effects, the evaporation flux from the Han River basin, Korea was estimated as a part of Carbo/HydroKorea project. The Han River basin and its tributaries are the focus of inter-disciplinary efforts to understand water and carbon exchanges in typical Korean forest catchments. The Han River basin is located in the middle part of the Korean peninsula. The drainage area (26,128 km^2) consists of temperate mixed forests and croplands. The mean annual precipitation in the Han River basin is 1301 mm (34.0 km^3) and the mean annual discharge is reported as 18.9 km^3. Approximately ~20 % of total rainfall is reported as interception in many studies for Korean forests and therefore, assuming a steady state, the mean annual evapotranspiration (ET) flux is estimated as 8.3 km^3. Evaporation from the basin has not been estimated quantitatively.

The isotope composition of river water collected monthly from the Han River and its tributaries is similar to that of monthly composite precipitation in the basin. In other words, in $\delta^{18}O - \delta D$ cross plot, the isotope ratios of river water do not show deviation from the MWL that is commonly observed in many evaporating systems. The result is intuitively interpreted as indicating an insignificant evaporation flux from the Han River basin. Evaporation is also not recognized from smaller tributary watersheds with spatial scales ranging from ~2 km^2 to ~10^3 km^2. Similar stable isotope results were reported for many watersheds in temperate regions of the world.

The results merit further discussion. First, as indicated by the isotopic composition, evaporation can be truly negligible in the forest watersheds. However, this interpretation does not support the model-based results indicating a significant evaporation flux from soils. Second, the isotope fractionation model originally developed for open-water evaporation may not properly explain the processes occurring during soil evaporation. Few studies have been conducted on stable isotope fractionation during evaporation in dry soils and in vegetated soils. Even fewer studies have been done for soils covered with litter layers. Third, the soil evaporation may largely occur during dry period after shedding leaves and due to low soil moisture content, soil water does not recharge into groundwater or discharge into stream (river). In this case, evaporation effects are only preserved in soil water and are not identified in the water discharged from watersheds. In this regard, the uncertainties of isotope techniques, isotope fractionation model for soil evaporation and relevant hydrological information are being thoroughly reviewed to verify the evaporation flux in the Han River basin.

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P44

ISOPRENE EMISSION FROM *QUERCUS SERRATA* IN THE DECIDUOUS BROAD-LEAVED FOREST

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Isoprene is a biogenic volatile organic compound (BVOC) emitted by many plant species. Isoprene emission contributes to the reactive carbon budget entering the troposphere. In Japan efforts to measure and understand the mechanism controlling BVOC emissions and to establish their emission inventories for the country have not been extensive, despite the fact that Japan has a large area of forests composed of coniferous and/or deciduous tree species (about 70% of total land area) and that forestry statistics across Japan are available (Tani et al. 2002).

Methods

The measurements were taken in the deciduous broad-leaved forest, Yamashiro, Kyoto (34°47N, 135°50'E). During June, July, August and October 2006, the isoprene emission, net assimilation rate, stomatal conductance, photo-synthetically active radiation (PAR), air and leaf temperature, relative humidity was measured on using a LI-6400 portable photosynthesis system (Li-Cor Inc., Lincoln, NE, USA)

Isoprene samples from the LI-6400 cuvette were trapped by adsorbents (Tenax 200mg and Carbotrap 100mg) packed into stainless steel tubes (Perkin Elmer) and stored at <5°C until analysis. Samples were analyzed using GC-MS system (Shimadzu QP5050A). Samples underwent two stage thermal desorption (Perkin-Elmer ATD).

Results

Fig. 1 shows the obvious effect of PAR on isoprene emissions and photosynthesis rates. Isoprene emissions reached their peak around noon, while for sun leaves the largest photosynthesis rates during morning and the subsequent decrease were observed as shown in Fig. 2.

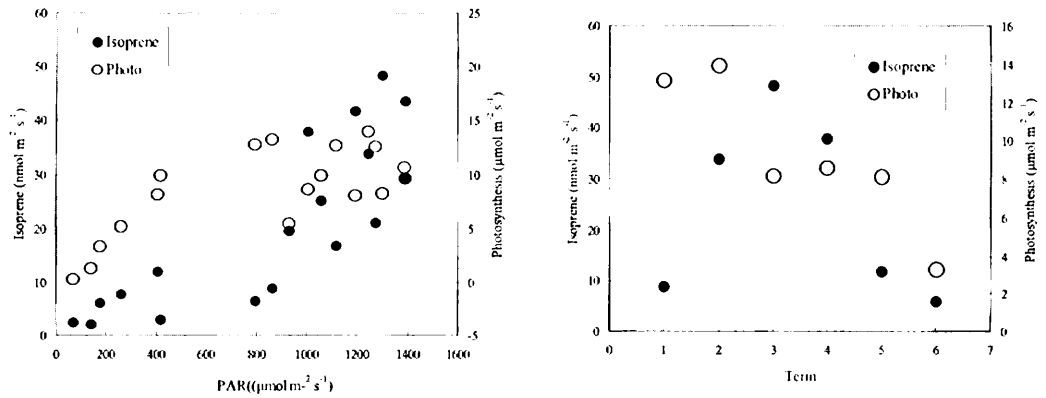

Fig. 1. Isoprene emissions and photosynthesis rates as a function of *PAR* (left)

Fig. 2. Temporal variations of isoprene emissions and photosynthesis rates for sun leaves on July 1 2006. Sampling term (1: 7:00-9:00, 2: 9:00-11:00, 3: 11:00-13:00, 4: 13:00-15:00, 5: 15:00-17:00, 6: 17:00-18:30), number of samples: 4-6 leaves. (right)

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P45

CH_4 AND N_2O EMISSION FLUXES OF MIRE SOILS IN SANJIANG PLAIN, NORTHEAST CHINA

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The fluxes of CH_4 and N_2O emission in four types of mire soil were measured, using the opaque chamber and gas chromatogram technique in Sanjiang Plain, northeast of China. For the differences of hydrological condition and vegetation type, the observation sites were selected in Carex lasiocarpa and Carex pseudocuraica (continuously inundated) mire, Deyeuxia angustifolia (seasonal inundated) mire and brushwood meadow soil.

During the observation, fluxes of the two types greenhouse gases were mainly focused on the growing season (June to August), that was the high temperature and precipitation season. However, the largest fluxes of CH_4 and N_2O appeared in different types of mire soil, respectively. The flux of CH_4 emission was mainly affected by the mineralization of organic matters, soil respiration, and the processes of heat exchange and so on. During our observation, the mean flux was larger in Carex lasiocarpa (7.67 mg $\cdot$ m^{-2} $\cdot$ h^{-1} on average) and Carex pseudocuraica (3.38 mg $\cdot$ m^{-2} $\cdot$ h^{-1} on average) mire soil (continuously inundated). However, there were no significant seasonal differences in inundated Deyeuxia angustifolia mire and brushwood meadow soil (0.28 mg $\cdot$ m^{-2} $\cdot$ h^{-1} on average). The flux of CH_4 appeared decreasing with the decrease of water level in soil. The mean fluxes of N_2O were positive in the four types mire soil, that was the source of N_2O to atmosphere during the entire observation. Brushwood meadow soil had the largest flux of N_2O (0.041 mg $\cdot$ m^{-2} $\cdot$ h^{-1} on average). Then were Deyeuxia angustifolia mire soil (0.038 mg $\cdot$ m^{-2} $\cdot$ h^{-1}), Carex pseudocuraica mire soil (0.024 mg $\cdot$ m^{-2} $\cdot$ h^{-1}), Carex lasiocarpa mire soil (0.017 mg $\cdot$ m^{-2} $\cdot$ h^{-1}). Hydrological condition and soil temperature were the main influencing factors controlling mire soil CH_4 and N_2O emission fluxes. Soil temperature was the main factor controlling soil respiration, but the CH_4 and N_2O emission fluxes intensity and their features were affected significantly by the hydrological condition.

P46

EDDY COVARIANCE MEASUREMENTS OF CH_4 FLUX IN A JAPANESE RICE PADDY FIELD

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Rice paddies are major source of atmospheric CH_4 in spite of their importance to the global food production. The accurate monitoring in CH_4 emission is essential to understand its behavior and achieve the methane mitigation. We conducted the measurement in CH_4 flux using the eddy covariance method (EC-F_{CH_4}) with the closed-pass type methane gas analyzer over Japanese rice paddies, "Mase paddy flux site", located in the middle of Japan during the growing season in 2003. Methane mixing ratio (ρ_{CH_4}) of 10 Hz frequency was measured by a frequency-modulated tunable diode laser absorption spectrometer (TDLAS), when the response of 2.4 Hz derived from gas replacement in the volume of the detector are achieved in situ.

Spectral power distribution of ρ_{CH_4} computed by using the fast Fourier transform (FFT) appeared as a representative ogive, which showed the source signals had a sufficient coverage to perform flux calculation. On the momentum-ρ_{CH_4} cospectra, we found that the major power range of methane flux contribution located in lower frequency compare to the other fluxes such as the sensible heat, the latent heat and CO_2, which means the EC-F_{CH_4} are transferred with relatively large turbulences. It may depend on a physical response of the rhizospheric soil where the methane emission and production take place in relation to the heat capacity.

EC-F_{CH_4} provides the typical diurnal variations; they followed by an increase in emission rate from 30 days after flooding in the range of 1 $\mu g\text{-}CH_4\ m^{-2}s^{-1}$ in the daytime. In the seasonal variation, they increased to 80 $mg\text{-}CH_4\ m^{-2}\ day^{-1}$ in mid-Jun (60 days after flooding) and exceeded 100 $mg\text{-}CH_4\ m^{-2}\ day^{-1}$ in mid-July. Especially in the mid-term and final drainage event, approximately 400 ~ 500 $mg\text{-}CH_4\ m^{-2}\ day^{-1}$ of causal large emission was observed. We compared EC-F_{CH_4} to the other CH_4 flux by an advanced aerodynamic method using vertical CH_4 profiles which were measured simultaneously. Although the half hourly EC-F_{CH_4} were scattered while the minuscule emission period due to the signal to noise ratio within ρ_{CH_4}, the two fluxes principally agreed under certain emission period.

We discuss the behavior of the CH_4 turbulence transfer in flux calculation. There were no dependency in non-dimensionalized variations for CH_4 (σ_{CH_4}/ CH_4*) on atmospheric stability under the neutral and stable conditions, and the gradient profile function in CH_4 (Φ_{CH_4}) shows almost similar characteristics to past studies in other scalar fluxes. We consider that the assumption which the eddy diffusivity for CH_4 behaves as in sensible heat flux, based on the Monin–Obukhov similarity, can be reasonably employed.

P47

THE EFFECT OF LOGGING ON SOIL GREEN HOUSE GAS (CO_2, CH_4, N_2O) FLUXES IN TROPICAL HUMID FOREST, PENINSULAR MALAYSIA

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Quantifying soil CO_2 flux is critical to understand the overall response of the carbon cycles to human perturbation worldwide. CO_2 accounts for most of the anthropogenically driven increase in radiative forcing. Moreover, methane (CH_4) and nitrous oxide (N_2O) are also important green house gas, whose concentrations in atmosphere have increased by human activities. The CH_4 increase accounts for 20 % of the increased green house warming potential of the atmosphere. The N_2O contributes about 6 % of the green house warming.

IPCC (2001) pointed out that the logging or land use change in tropical zone can affect the global warming strongly. Soils are an important source and sink of these green house gases (GHG: CO_2, CH_4, N_2O). Therefore, it is important to understand the effect of logging on soil GHG fluxes in tropical area. However, a little work on the these gas fluxes has been carried out in Southeast Asia, which is one of the largest tropical regions in the world and an area of significant logging during the last three decades.

The aims of the present study are to evaluate soil GHG fluxes in logged and un-logged forest in tropical Asia and to understand the effect of logging on the soil GHG fluxes.

We carried out the investigation of the soil GHG fluxes in Pasoh forest (2° 58'-59'N, 102° 16'-20'E) in Peninsular Malaysia. One compartment of Pasoh forest was logged selectively on January 2005. The logged area is about 37 ha and 1004 trees were collected from this area. Soil GHG fluxes were measured at daytime in the logged sites and the un-logged sites within the compartment area on February, May, June, July 2005 and March 2006.

The soil CO_2 emission rates in the un-logged sites did not differ from those in the logged sites significantly except for June 2005 (Fig. 1a). The soils in the un-logged sites absorbed CH_4 throughout the experimental period, while those in the logged sites absorbed or emitted CH_4, close to zero, except for February 2005 (Fig. 1b). The soil CH_4 absorption rates in the logged sites tended to be less than those in the un-logged sites. The soil N_2O emission rates in the logged sites were about 3-100 times higher than those in the un-logged sites significantly throughout the experimental period (Fig. 1c). The logging practices had increased the soil N_2O emission rates throughout the experimental period, one year after the logging.

These above results suggest that logging practices in humid tropical forest affect soil CH_4 and N_2O fluxes, which can accelerate global warming throughout one year after logging, while do not affect soil CO_2 fluxes.

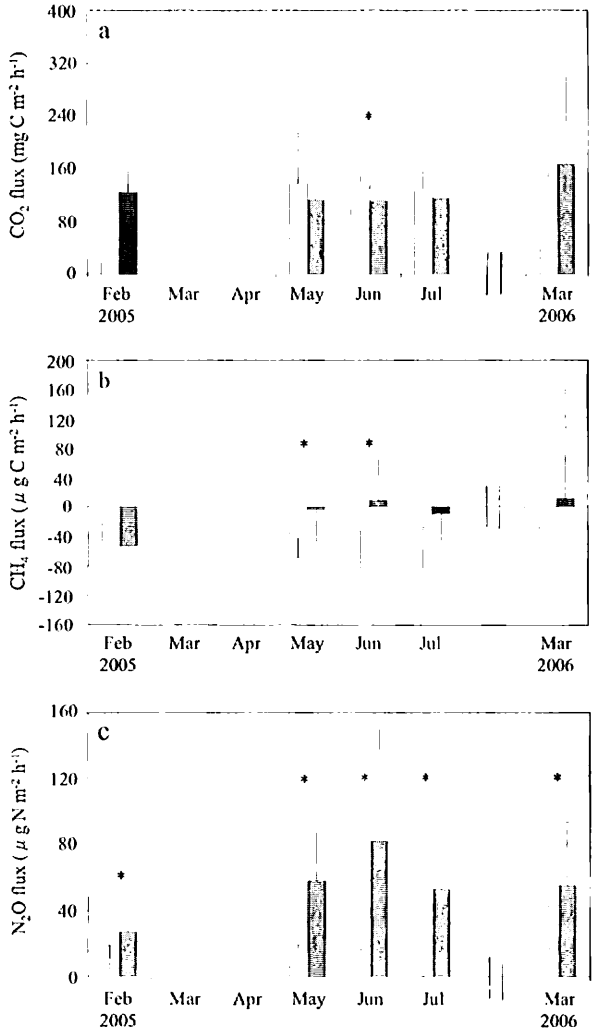

Figure 1. Mean value and standard deviation of monthly (a) CO_2, (b) CH_4 and (c) N_2O fluxes in logged and un-logged sites. ☐ ; Un-logged sites, ☐ ; Logged sites. An asterisk means the significantly difference between logged and un-logged sites in same month by ANOVA ($P<0.05$).

P48

Effects of typhoon damage on the vegetation properties and carbon dynamics in a larch forest

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1.Introduction

Typhoon is an important disturbance factor for forest ecosystems in East Asia, which damages them extensively and intensively. It is thought that the disturbance affects ecosystem properties including vegetation dynamics, nutrient cycling, soil organisms and micrometeorology, and consequently changes carbon cycling of forest ecosystems. In particular, the function of forest ecosystems to fix carbon after disturbance is important from the standpoint of global warming.

A plantation of Japanese larch (*Larix kaempferi* Sarg.) in Tomakomai, Hokkaido, Japan was destroyed by Typhoon Songda in September 2004. About 90% trees were blown down by strong wind. In this study, we compare vegetation properties, biomass and soil carbon content before and after the typhoon damage, and investigate the effects of the typhoon damage on carbon cycling of larch forest.

2.Methods

The study site is Tomakomai Flux Research Site in, Hokkaido, Japan (42°44'N, 141°31'E). This site was established in August 2000 by the National Institute for Environmental Studies (Fujinuma *et al.*, 2001). However, in September 2004, Typhoon Songda hit it and blew down 90% of trees. Before the typhoon damage, this forest was a 45–year-old plantation of Japanese larch with some broad-leaved trees (*Betula* spp). The canopy height was 15-16m, and the maximum leaf area index (LAI) was 5.8 m^2 m^{-2}. The forest floor was densely covered with buckler fern (*Dryopteris crassirhizoma*) and Japanese spurge (*Pachysandra terminalis* Sieb. et Zucc.). After the typhoon, all stems of larch trees were removed from the forest for commercial use.

Fig.1. Location of the stydy area

We established a 140x100 m (1.4 ha) plot in the site in 2005, about one year after the typhoon damage. To measure aboveground biomass, we established 10 rectangular plots (1x6 m); each plot was divided into 6 subplots (1x1 m). Aboveground biomass was sampled monthly from June through November in 2006 for every dominant species. Similar data of understory species in 2001 was used for comparison.

To evaluate the total amount of carbon stored in the site, tree biomass was calculated from data of diameter at breast height (DBH) using an allometric regression equation. Soil carbon content at 0-2.5 cm depth was measured in November 2005.

Fig.2. View of the stydy area (August 2006)

3.Results and Discussion

Live aboveground biomass of understory species or invaded herbaceous species was 2.7 ton ha^{-1} in 2001 before the typhoon damage and 2.7 ton ha^{-1} in 2006. There was no difference in aboveground biomass. However, plant species changed. Dominant species was pteridophyte (buckler fern and so on) in 2001 but was nettle in 2006.

The carbon of dead biomass left in the site was estimated at 30.3 tC ha^{-1}; 16.4 tC ha^{-1} for larch trees and 13.9 tC ha^{-1} for broad-leaved trees. The dead biomass has been decomposed to CO_2 and changed to soil organic matter. Soil carbon content was 15.8% (±8.5%) in 2005. It was similar with a published value of 16.0% in 2000 (Yamamoto *et al.*, 2001).

P49

SOIL RESPIRATION IN A SUBTROPICAL MONTANE CLOUD FOREST IN TAIWAN

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The measurement of soil respiration was conducted from May 2005 to April 2006 in a long-term biogeochemical study site located in the mid-altitude of a mountain range of north Taiwan. The dominant species, *Chamaecyparis obtusa* var. *formosana* is characterized by very long life (up to 3000 years) and low growth rate, which might result from the perhumid climate condition and low solar radiation caused by fogs all year round. Besides the limitation of high humidity both in the air and in the soil (annual precipitation usually higher than 3000 mm), the metabolic performance of this cypress tree species might be also constrained by the relatively low temperature (annual average 13.6 °C) compared to the environment of lowland subtropical trees. Based on these information, a low soil respiration rate was proposed for that forest ecosystem.

The major carbon pools and internal flux of the site was investigated in the previous studies. *C. obtusa* var. *formosana*, which consists 83% of the total basal area, contains 43.8 and 37.2 t C ha^{-1} for the above and belowground parts, respectively. The soil of the site is a Lithic Leptosol and contains only 27.3 t C ha^{-1} due to high stone composition. The aboveground litterfall amounts to ca. 3.0 t C ha^{-1} y^{-1}.

An automatic chamber system (LI-COR 8100 with long-term chamber) was setup on the forest floor. The place was chosen based on three one-day measurements using 10 static chambers that were randomly put on a 40 x 40 m^2 area. Soil respiration rate was measured every 30 minutes with 5-min closure of the chamber. Soil temperature and soil water content at 10 cm depth were monitored together with other meteorological parameters. Soil respiration rate increased exponentially with increasing soil temperature and decreased exponentially with increasing soil water content. The range of soil temperature during the experiment period was 4 to 18 °C, while that of soil water content was 0.25 to 0.47 cm^3 cm^{-3}. The soil respiration rate of single measurement ranges from 6 to 395 mg CO_2 m^{-2} hr^{-1}. We derived from these data an empirical model for soil respiration rate [mg CO_2 m^{-2} hr^{-1}] : Flux = 1.16*exp(0.279*ST)+4809*exp(-13.34*SW) (ST: soil temperature in [°C]; SW: soil water content in [%]; R^2=0.96). An annual soil respiration rate of 2.0 Mg C ha^{-1} y^{-1} for our study site was estimated when upscaling the point flux rate to the site that has 92.5% area of soil (the rest of the area is covered by stones and falling logs).

The contribution of fresh aboveground litter decomposition to soil respiration was investigated using manipulated plots with different amount of addition of *C. obtusa* var. *formosana* leaves. Three groups of transparent acrylic chambers (inner diameter: 29 cm, height: 20 cm) were randomly put on forest floor (each group with four replicates). The treatments of the three groups were three-fold annual litter, one-fold, and no litter. The chambers were covered with plastic net (mesh size: 1 mm). Soil respiration rates were measured by 24-hr static alkali method in 13 dates, three of which were done before the litter treatment. The result showed a significant increase in soil CO_2 efflux immediately after the artificial input of leaf litter. The difference between the treatments diminished gradually and the soil respiration rates decreased to the pre-treatment level in 6 months. The total releases of CO_2 within 6 months were estimated to be 120, 85, and 69 g C m^{-2} for the three-fold, one-fold, and no litter group, respectively. About 8% of the added carbon in the litter released in form of CO_2. Comparing the release of CO_2 between one-fold and no litter treatments, we concluded that 20% of the soil respiration comes from fresh litterfall within first 6 months of litterfall. The contribution of soil respiration in the ecosystem carbon budget will be evaluated by comparing the results of this study with the tower measurement of canopy CO_2 exchange by eddy covariance technique, which was conducted in the same time period at the site.

P50

EFFECT OF SOIL-COLLAR INSERTION ON SOIL RESPIRATION IN SECONDARY DECIDUOUS BROAD-LEAVED FOREST

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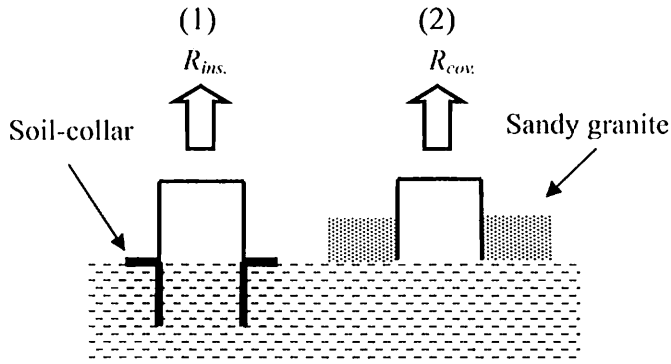
Soil respiration is one of the most important factors for estimating CO_2 dynamics in the forest ecosystem. For measuring soil respiration, soil-collar is commonly inserted to the ground to remove the influence of wind flowing through soil surface. But inserting soil-collar causes occurrences such as cutting off live roots and as interfering with approach of next live roots. However there is little information about the effect of disturbance by inserting soil-collar on soil respiration measurement. In this study, we investigate the effect of inserting soil-collar temporally and spatially.

This study was conducted in a secondary deciduous broad-leaved forest dominated by *Quercus serrata* and *Ilex pedunculosa*. The soil is poorly developed from sandy weathered granite soil with thin A layer. The depth of A layer is about 10 cm. We made chambers of two types: One was that soil-collar was inserted in the ground about 6 cm (Fig.(1)). The other was that soil-collar was covered the surroundings by sandy granite without inserting to the ground (Fig.(2)). We defined $R_{ins.}$ and $R_{cov.}$ as measured soil respiration in respective chambers. To investigate the temporal effect of soil-collar insertion, an automated closed-chamber system was used. The system was composed of IRGA (model 800, LI-cor) , two chambers and a pump. Observations were made from June to October 2006. Measurement frequency of soil respiration was once an hour in each chamber. And to investigate the spatial effect of soil-collar insertion, we established another plots in ridge and valley of the experimental forest. A manual closed-chamber system that contained a small IRGA (GMD20, Vaisala) was used there. We measured $R_{ins.}$ and $R_{cov.}$ at each 8 points in ridge and valley plot in intensive observations. In both experiments, soil temperature was monitored by thermocouple at depth of 5 cm and soil moisture was monitored by TDR (ECH2O Probe, Decagon Devices) at depth of 5 cm.



Through measurement periods, soil respiration in the inserting soil-collar treatment ($R_{ins.}$) was always smaller than soil respiration in the covering the surroundings by sandy granite ($R_{cov.}$). $R_{ins.}$ was about 6.3% - 85.4% of $R_{cov.}$ and it was about 27.8% on average. Therefore, it was suggested that soil respiration was underestimated when we used inserting soil-collar system. Particularly $R_{cov.}$ had a large temporal variation with the maximum occurring in high temperature and moisture. And $R_{ins.}$ was significantly smaller than $R_{cov.}$ in ridge plot and valley plot. ($P<0.01$, Student t-test). In ridge plot, $R_{ins.}$ was about 57.1% - 70.3% of $R_{cov.}$, and it was about 63.9% on the average. In valley plot, $R_{ins.}$ was about 48.0% - 54.7% of $R_{cov.}$, and it was about 51.48% on the average. It was suggested that if environmental factors resembled closely, $R_{ins.}$ was also spatially smaller than $R_{cov.}$ We found that soil respiration was temporally and spatially underestimated by inserting soil-collar at this study site. When we measure soil respiration, we must take a method that does not disturb soil as much as possible.

P51

ABOVE AND UNDERGROUND RESPIRATION IN A DECIDUOUS BROADLEAVED FOREST

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1. INTRODUCTION

Ecosystem respiration can be measured at night by means of the eddy covariance method, but the data may not be reliable because of low turbulence or other methodological problems. Adequate atmospheric mixing is required to obtain reliable measurements of the flux between ecosystem and atmosphere with this method; however, low wind speeds at night are common in our study area, the Yamashiro Experimental Forest (YEF). Consequently, the estimation of nocturnal respiration requires the use of a chamber method. To understand how trees control their CO_2 flux in this forest, we measured above and underground respiration in the forest using a static automated chamber method. In the present study, foliar and woody-tissue respiration was measured using automated foliage chambers, including periods when growth respiration was occurring. In this study, we estimated the above and underground respiration in YEF.

2. SITE DESCRIPTION AND METHODS

The YEF is located in a valley in Yamashiro-cho (34°47'N, 135°51'E), Soraku-gun, Kyoto, in a hilly, mountainous region of central Japan and at an elevation of about 220 m asl. The forest consists of deciduous broadleaved species (mainly *Q. serrata*) and evergreen broadleaved species (mainly *I. pedunculosa*). We measured the leaf area index (LAI) of the forest once per week with an LAI-2000 (Li-Cor). Based on the seasonal variation in the LAI, and the measured foliar respiration, we were able to estimate total foliar respiration for the forest (Miyama et al., 2005). We also measured the diameter at breast height (DBH) of all trees in the YEF every 5 years (Goto et al., 2003). In this study, we measured seasonal variations in nocturnal respiration of tree using static, automated chambers in the YEF. The chamber automatically measured nocturnal respiration at 30-min intervals. We measured the relationship between DBH and the surface area of woody tissue in the trees, estimated total surface area in the YEF, and scaled up stem respiration to the whole forest level to estimate respiration by woody tissue. We attached chambers to *Q. serrata* and *I. pedunculosa* (DBH, 20.7 and 17.9 cm, respectively) tree. The air temperature within chamber was measured with a copper-constantan thermocouple. Nocturnal respiration per unit area of *I. pedunculosa* and *Q. serrata* were calculated from the difference in CO_2 concentrations between 30 and 210 sec (3 min) in chambers.

3. RESULTS AND DISCUSSION

The contribution of underground respiration to the total ecosystem respiration rate reached its minimum (49.1%) on 12 June (DOY 163) and its maximum (82.4%) on 29 November (DOY 333). Seasonal change of growth respiration was marked, indicating that the seasonal variation of growth respiration must be evaluated carefully to estimate total ecosystem respiration. According to continuous automated chamber measurements, the seasonal change of nighttime ecosystem respiration was controlled by growth respiration in a deciduous broadleaved forest. There were two marked peaks of growth respiration, which were caused sequentially by foliar and woody-tissue respiration. These results indicate the effectiveness of averaging long-term continuous chamber measurements to evaluate the annual nighttime ecosystem respiration. Seasonal variation of nighttime ecosystem respiration should be estimated using several parameters, including phenological data. By using the automated chamber method, the total nighttime ecosystem respiration was estimated continuously, thus allowing seasonal patterns to emerge. Therefore, long-term continuous measurement using automated multi-channel chambers and averaging provides an effective means of evaluating the annual nighttime ecosystem respiration.

REFERENCE

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P52

AUTOMATIC SOIL RESPIRATION MEASURING IN THE TROICAL SEASONAL EVERYGREEN FOREST IN SAKAERAT, THAILAND

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The present study was aimed to determine soil respiration in dry evergreen forest at the Sakaerat Environmental Research Station, Nakhon Ratchasima, Thailand (14°29'29''N, 101°55'05''E, elevation 535 m.a.s.l.) during 2005-06. Soil respiration was determined by hourly automated closed chamber method, operated with a CR10 data logger (Campbell Scientific). Soil respiration was measured using closed-part CO_2 Analyzer (LI-820, Licor) and pneumatic cylinder system chamber which is 20 cm in diameter and 20 cm height. Soil moisture contents at 10 and 50 cm depths were measured using TDR (CS615, Campbell Scientific). Rainfall and soil temperature also were recorded by an automatic weather station throughout the study.

The hourly soil temperature, rainfall, soil moisture content at 10 cm depth and soil respiration data during study period are displayed in Figure 1. The results showed that there were remarkable seasonal changes in the soil respiration rate and soil moisture content at 10 cm depth. Soil respiration rates in rainy season (July-November) were found to be greater than those in dry season (December-June). The highest soil respiration rate was found to be 11.220 umol/m^2/s in November while the lowest one was 1.241 umol/m^2/s, found in February. The soil respiration rates varied significantly with soil moisture content at 10 cm depth with r = 0.76.

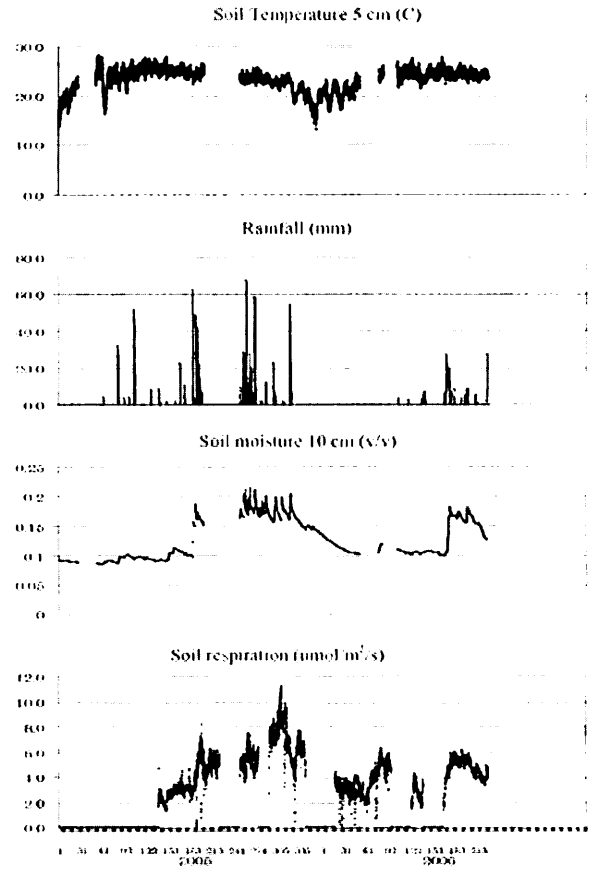

Figure 1 The hourly soil temperature, rainfall, soil moisture content at 10 cm depth and soil respiration data during study period

P53

EFFECT ESTIMATION OF ENVIRONMENTAL FACTORS AND SOIL PROPERTY ON TOPOGRAFICAL VARIATION OF SOIL RESPIRATION - THE CASE OF EXTREMELY IMMATURE AND MATURE FOREST SOIL

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The topographical variation of soil respiration (F_c:mgCO_2m^{-2}s^{-1}) and the effect by environmental factors and soil property are compared between extremely immature forest soil in Yamashiro Experimental Site (YES), Kyoto, Japan and mature forest soil in Kahoku Experimental Watershed (KHEW) in Kumamoto, Japan.

The two observation sites were settled at ridge and bottom of gully. The difference of altitude between them is around 30m. F_c was measured by automated chamber installed IRGA from July 2004 to June 2005 in YES. The four observation sites were settled at top, upper, middle and base part of south faced slope with around 70m height. Each plot had 24 colors and measured F_c by manual chamber installed IRGA at once or two times in a month from August 2005 to August 2006 in KHEW. The soil temperature (T_s: °C) and soil moisture (□: m^3 m^{-3}) at 5cm depth were also monitored at every 6 plots.

When F_c was expressed with Eq.(1) for each plot, parameters a, b and c were gained as Table 1.

$$F_c = aExp(bT_s)(\frac{\theta}{\theta + c}) \qquad (1)$$

Table 1 The parameter values in Eq.(1) at each plot

	YES			KHEW		
	Ridge	Gully	Base	Middle	Upper	Top
a	0.1111	0.0424	0.0159	0.0357	0.0464	0.0904
b	0.1000	0.0878	0.0890	0.0969	0.1049	0.0619
c	0.6752	0.1368	0.1989	0.4716	0.6935	0.4648

The difference of estimated annual F_c from the standard plot was –0.46tCO_2ha^{-1}year^{-1} in YES and –9.45 - +1.27tCO_2ha^{-1}year^{-1} in KHEW. The standard plots were bottom of gully and middle part of slope in YES and KHEW, respectively. The effects of T_s, □ and parameters in Eq.(1) on the difference of F_c were shown in Table-2. The large absolute values of each effect means the large effect on the difference of F_c. The result reported by Palmroth *et al.* (2005) was also shown in Table 2. They dealt with the adjacent forests on flat terrain in north-west USA.

In KHEW, the parameter effects were larger than other cases. The parameter effect is thought to indicate the effect of the soil property difference. The soil in KHEW was thought to mature individually in each topographical part by individual condition. Thus, the soil property is supposed to be different from each other at each topographic part and effect on the soil respiration individually. In the case reported by Palmroth *et al.* (2005), the forests were located on the flat terrain and soil property difference between plots is supposed to be smaller than KHEW.

On the contrary, the parameter effect in YES is much smaller than other case. The forest soil in YES is extremely immature and the difference of soil property at each topographic part is thought to be small and effect on the soil respiration in similar.

Table 2 Estimated effect of environmental factors and parameters in Eq.(1)

	YES			KHEW			NE-USA(Palmroth et al 2005)	
	Ridge	Gully	Base	Middle	Upper	Top	Pine Plantation	Hard Wood
Estimated F_c (tCO_2ha^{-1}year^{-1})	21.56	21.10	14.42	23.87	25.13	24.79	41.80	51.66
Deifference of Fc from the standard site (tCO_2ha^{-1}year^{-1})	Standard site	-0.46	-9.45	Standard site	1.27	0.92	Standard site	9.86
Effect of θ (tCO_2ha^{-1}year^{-1})		1.66	3.89		-1.90	-4.55		2.79
Effect of T_s (tCO_2ha^{-1}year^{-1})		-2.10	-1.74		-0.48	-0.54		4.40
Effect of parameters (tCO_2ha^{-1}year^{-1})		0.20	-9.84		4.41	7.61		2.67

Reference: Palmroth *et al.* 2005. Global Change Biology. 11: 1-14.

P54

THE EVALUATION OF ROOT RESPIRATION USING SOME MATHODS IN TEMPERATE DECIDUOUS FOREST OF CENTRAL JAPAN

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When we evaluate the net ecosystem exchange of CO_2 in forest ecosystems using the eddy covariance methods, it is necessary to compare the input and output of carbon to/from compartments that forest composed of. Because measurements of each component of respiration are required to provide a complete picture of carbon exchange for a complex forest, the chamber method may offer a significant advantage over the eddy covariance method because it provides accurate, continuous, direct measurements of respiration that are largely unaffected by atmospheric conditions such as wind. Moreover, belowground processes play an important role in the carbon cycle of the biosphere. Soil respiration is the main pathway for carbon moving from the ecosystem into the atmosphere (Ryan and Law, 2005) and can strongly influence net ecosystem exchange. However, the efflux from a soil surface is an assemblage of multiple belowground processes such as decomposition respiration and root respiration. In this study, we try to evaluate each compartments of forest carbon cycle using respiration measurements and biomass measurements.

The study was conducted in a mixed forest of deciduous and evergreen broad-leaved trees including some conifers at Yamashiro Experimental Forest in Kyoto. The area consists of very thin soil layer, immature and originated from granite. Kominami et al. (2003) measured CO_2 exchange by eddy covariance methods.

We measured forest biomass in study site and litter and CWD input to forest floor. We measured *Rs* at many points and *Rr* with many samples by chamber method. We developed an automatic chamber system for measuring CO_2 flux of fine root. At the same time, *Rs* and CO_2 flux from B layer were measured. At each chamber, CO_2 flux was measured at 35-min intervals, and soil temperature and water content were measured continuously from April 2004 to May 2005. We combined some methods for estimation of *Rr* because it is difficult to build the technique to separate accurately *Rr* from *Rs*.

From annual measurement of *Rr* and *Rs*, we estimated the carbon output from forest floor. We found the differences of responsibility to environmental factor between root and soil respiration. These results suggested that it is important to analyze *Rr* separately for discussion and modeling forest carbon cycle. Moreover, we found that fine root plays an important role in belowground carbon cycle and the importance of measurement of root litter, though there is no data yet.

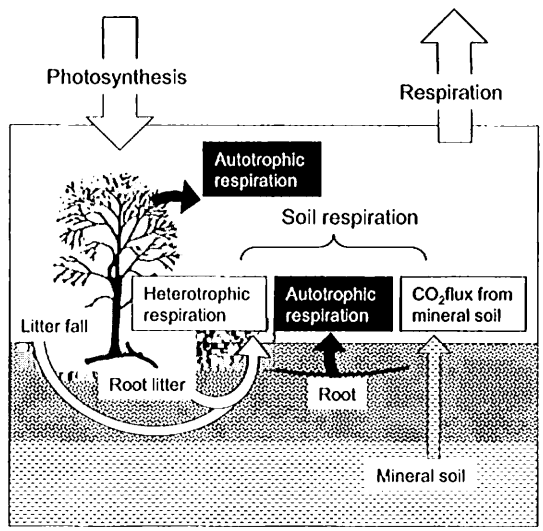

Fig 1. The illustration of carbon cycle of forest

P55

CONTRIBUTIONS OF ROOT AND MICROBIAL RESPIRATION TO SOIL RESPIRATION FOR *ABIES HOLOPHYLLA* AND *QUERCUS MONGOLICA* STANDS OF CENTRAL KOREA

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To investigate contributions of root and microbial respiration to total soil respiration, trenched plots and control plots were set up in *Abies holophylla* and *Quercus mongolica* stands at Gwangneung Experiment Forest of central Korea in October 2004. Soil respiration, soil temperature, soil water content, soil pH, and soil microbial activity were measured from June, 2005 through May, 2006. There were no differences in total annual soil respiration (t C/ha/yr) between *A. holophylla* (9.4) and *Q. mongolica* (7.9) stands. Contribution of root respiration to total annual soil respiration was 39% for *A. holophylla* and 35% for *Q. mongolica* stands. Soil temperature was not different between *A. holophylla* (13.2□) and *Q. mongolica* (14.6□) stands. Soil water content for the *A. holophylla* stand (12.8%) was lower than that (14.2%) for the *Q. mongolica* stand. Soil pH for the *A. holophylla* stand (4.8) was lower than that for the *Q. mongolica* stand (5.0). Soil microbial activity (μg hydrolyzed FDA/min/g dry soil) for the *A. holophylla* stand (8.2) was higher than that for the *Q. mongolica* stand (6.5). Soil respiration for both stands was related with soil temperature ($p<0.001$). And soil respiration for the *Q. mongolica* stand was related with soil microbial activity ($p<0.01$), however, that for the *A. holophylla* stand was not related ($p>0.05$). Contribution of root respiration to soil respiration for both stands was related with soil temperature ($p<0.05$) in the study period except winter.

Fig 1. The picture of estimating total soil respiration

P56

COMPARISON OF ECOSYSTEM RESPIRATION OF WINTER-WHEAT MEASURED WITH EDDY COVARIANCE AND STATIC CHAMBER

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Aim of the paper is to compare the measurements of ecosystem respiration of a winter-wheat cropland in North China Plain during the growing season(March to June) of 3 years(2003-2005) using eddy covariance and static/GC chamber. Most of the chamber measurement were made in darkness, either during nighttime or during daytime by covering wheat and ground. The average difference of air temperature inside and outside the chambers was 1.2℃ after data quality control for minimizing the environmental disturbance. Half-hourly nocturnal flux values were excluded when the friction velocity(u*) was <0.12 m s^{-1}, sensor variance was excessively high or extremely low, rain was falling. The available nocturnal half hourly data were 25%, 33%, 31% for analysis in growing season of 2003, 2004, 2005. The study showed that the measurements of ecosystem respiration using chamber at nighttime is 16% higher than that of eddy covariance during the growing season of 2003. Continual nocturnal half-hourly ecosystem respiration estimates of chamber were derived by extrapolating the relationship between diurnal ecosystem respiration and air temperature, LAI. Nocturnal eddy covariance measurements were good correlated to nocturnal chamber estimates in 2003(R^2=0.63) and were only 11% lower than the latter, but poorly correlated to chamber estimates of ecosystem respiration in 2004 and 2005. When the nocturnal friction velocity was 0.25-0.4 m s^{-1}, two measurements all had good agreement in the 2004 and 2005 which may suggest that the u* was an predictor of good nocturnal eddy covariance measurements. Correlations of daily nocturnal measurements by eddy covariance and chamber were good (R2=0.895, 0.515, 0.497) and chamber measurements had 10.7%, 38.5%, 2.4% higher than eddy covariance measurements during the 3 years.

DIVERSIFIED EVALUATION OF CARBON BALANCE AT WARM TEMPERATE FOREST IN JAPAN

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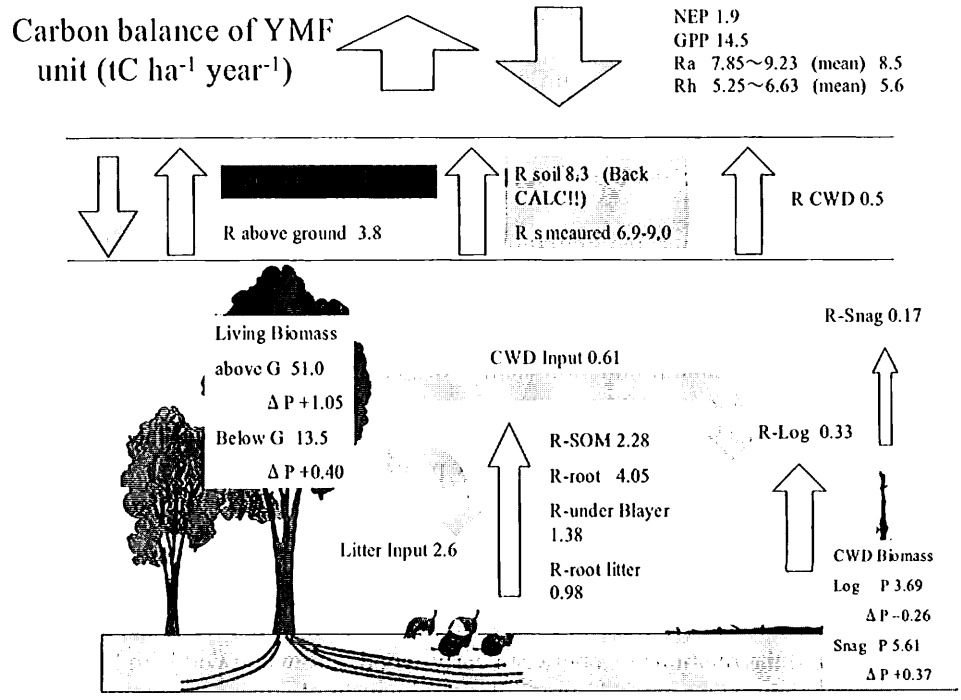
Estimation of carbon balance and structure of forest ecosystem is an important subject for long term evaluation of forest carbon dioxide exchange. In a temperate deciduous forest in Japan situated complex terrain, Total carbon balance was estimated using micro-meteorological method, chamber methods (leaves, stems, root, soil CWD) and biometric methods.

Materials and methods

The study was conducted in the Yamashiro Experimental Forest (temperate secondary broad-leaved forest in central Japan, 34°47'N, 135°50'E). *Quercus serrata* is a dominant species in the site. The area of the site is 1.7ha, annual mean air temperature was 15.5 °C and annual precipitation was 1449 mm in 2002. Tower CO_2 flux have been measured from 2000. Above and below ground net primary production were estimated based on allometric relationships and DBH census from 1994. CO_2 flux from foliages, stems and roots was estimated using automated chambers and LAI and root biomass measurements. CO_2 flux from soil (Fs) was estimated by 4 automated and 160 manual chambers. CO_2 flux from CWD was estimated by 2 automated and 192 manual chambers measurements and CWD census. Carbon balance of litter was estimated by RothC model and litter trap measurements. By integrating each CO_2 flux measurement and various censuses, carbon balance of YMF was estimated.

Results and Discussion

Comparing with daytime CO_2 uptake, nighttime respiration was relatively high in warm temperate forest caused by warm temperate environment. Therefore accurate estimation of nighttime respiration is required. Carbon accumulation in soil was considerably small caused by high decomposition rate comparing with C input in forest floor. As chamber measurements had high variations especially in soil respiration measurements, diversified evaluation using another measurements (eg. biometric) should be required in adopting chamber measurements in NEE estimation.



P58

LONG TERM ESTIMATE OF ABOVEGROUND PRODUCTION BY A TREE RING ANALYSIS IN A TEMPERATE BROAD-LEAVED SECONDARY FOREST IN JAPAN

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Influence of climate change due to increase of atmospheric CO_2 content on forest ecosystem should be evaluated. The long-term data of forest productivity is needed to evaluate the influence of climate change on net ecosystem production (Jacoby and D'Arrigo, 1997). The tree ring analysis is a useful method to calculate long-term annual aboveground production (AGP) which is important part of net ecosystem production's estimation (Graumlich et al, 1989).

The objective of our study is to determine long-term changes in AGP of a forest by a tree ring analysis. We estimated annual AGP as multiplied wood density by annual volume increment calculated from ring width. We examined annual AGP variation in relation to environmental factors such as monthly mean air temperature and monthly precipitation.

Materials and methods

The study was conducted in the Yamashiro Experimental Forest (temperate secondary broad-leaved forest in central Japan, 34°47'N, 135°50'E). *Quercus serrata* is a dominant species in the site. The area of the site is 1.7ha, annual mean air temperature was 15.5 °C and annual precipitation was 1449 mm in 2002. Tree census was conducted in 1994, 1999, and 2004. About 40 trees were harvested and allometric relationships were obtained for the biomass and production estimation in the site.

Method of this study was shown in Fig.1.

①Increment cores of *Q. serrata* (n=22) were obtained from the stem at the breast height

and each tree's ring widths were measured.

②Ring-width series of samples were cross-dated by visually, and cross-dating was verified by using COFECHA program. It was confirmed whether there was a synchronism among them by cross-dating.

③Biomass change of each sample tree was calculated using the ring-width series, wood density of each tree and the allometric relation between diameter at breast height and AGP.

④We assumed that the ecosystem biomass from 1994 to 2004 in the site was proportional to the summation of the biomass of 22 samples of *Q. serrata*, and applied the total biomass change in *Q. serrata* for current 20 years to the ecosystem biomass change in the site.

⑤We estimated annual production change of the site during this period as the annual difference of the biomass change.

⑥ We examined annual AGP variation in relation to environmental factors, such as monthly mean air temperature and monthly precipitation.

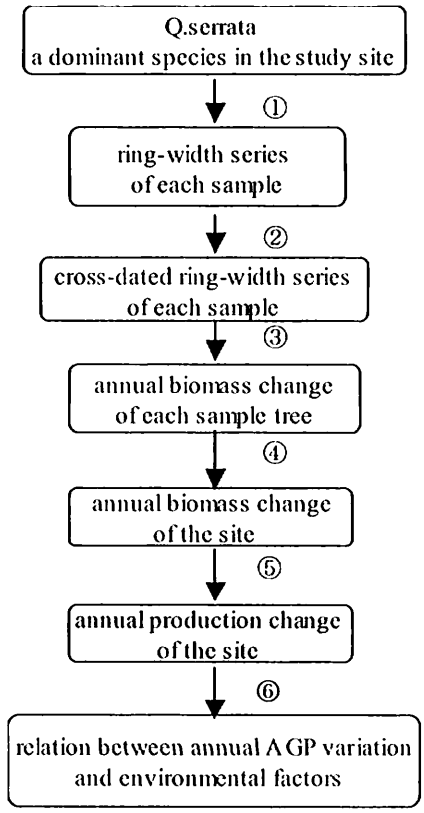

Fig.1 Method of this study

Results and Discussion

We could find the synchronism after 1980 among ring-width series of *Q.serrata*. The average annual production change was 2.3tC ha^{-1} $year^{-1}$, and it ranged from 2.6 to 1.1 tC ha^{-1} $year^{-1}$.

We analyzed the relationships between early-wood, late-wood width and environmental factors (monthly mean air temperature and monthly precipitation) by a simple linear regression analysis. As a result, late-wood width which highly contributed to annual ring width had a negative relation to summer temperature, and a positive relation to summer precipitation.

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P59

SEASONAL VARIATIONS IN LEAF AREA INDEX AT THE KOFLUX GWANGNEUNG WATERSHED IN KOREA

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Leaf area index (LAI) is one of the fundamental variables that are critical to analyze and synthesize various ecophysiological and biophysical measurements to ascertain water and energy exchanges in key terrestrial ecosystems. Information on LAI not only reflects the phenology of the site vegetation but also connects the changes in ecohydrological conditions to the observed fluxes of carbon and water at the study site. KoFlux Gwangneung forest (designated as a National Arboretum) is located in the west-central part of Korean Peninsula (37°45'25.37"N, 127°9'11.62"E, 280~470 m above m.s.l). The study site is dominated by an old natural broadleaf deciduous forest of *Quercus* sp. and *Carpinus* sp. (80-200 years old) along with scattered coniferous (e.g., *Abies holophylla*) and mixed forests, representing complex and heterogeneous landscapes of the country. We have measured LAI since 2001, using various methods at different locations at the site by different research groups. In this presentation, all the available LAI measurements made from April 2001 to September 2006 were combined and analyzed to characterize its seasonal variations at the site and to eventually compare with LAIs estimated from MODIS (Moderate Resolution Imaging Spectroradiometer) products. The information on the seasonal and spatial distributions of LAI, when combined with knowledge of other ecohydrological and biogeochemical measurements will provide a means of understanding and predicting components of energy, water and carbon cycles in this important ecosystem.

Acknowledgment: This study was supported by a grant (code: 1-8-2) from Sustainable Water Resources Research Center of 21st Century Frontier Research Program, the Eco-Technopia 21 Project and BK21 from the Ministry of Environment, Korea. And I am very thankful to Jeongshim Kim, Jaeyoung Lee and Kyunghee Kim for collecting data.

P60

DEVELOPMENT OF OUTDOOR INSTALLATION TYPE LASER SCANNER FOR CONTINUOUS MEASUREMENT OF TREE HEIGHT AND PLANT AREA DENSITY

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In order to estimate carbon storage and fixation of a forest, usage of the laser measurement technique was rapidly spread in recent years. For example, tree height was measured by an air-borne LIDAR and canopy structure was measured by a ground-based laser scanner (Takeda *et al.* 2005). But these measurements require high cost and were influenced by weather. The aim of this study is to develop the outdoor installation type laser scanner which can be measured automatically.

The outdoor installation type laser scanner was manufactured by attaching a laser range finder (LD90-3100HS, Riegl) put in a waterproof case to a pan-tilt rotation stage (PTU-D46-70, Directed Perception, Inc.) (Fig.1). It was placed at 28.7 m height on the CO_2 flux observation tower in Fujihokuroku Flux Observation Site (35°26′N, 138°46′E) in Fujiyoshida, Yamanashi, Japan. A measurement was conducted at night in every two days, because atmosphere was stable and noise of radiation to the laser range finder was little. The tree height was estimated from DCHM (Digital Canopy Height Model), which was calculated by difference of DTM (Digital Terrain Model) and DSM (Digital Surface Model), these were calculated from three-dimensional coordinates by which the laser beams were intercepted. The profile of plant area density (PAD) was estimated from a probability which the laser beams pass through the horizontal layers in the forest.

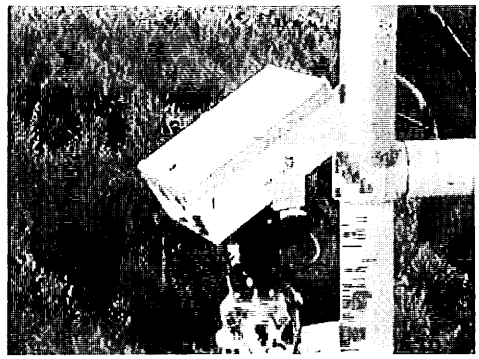

Fig. 1 Outdoor installation type laser scanner.

The laser scanner operated correctly in fine days, but it did not operate correctly in rainy days or foggy days. So, only data measured in fine days were used to calculate the tree height and the PAD. Fig.2 shows the distance image measured by the laser scanner in September 5, 2006 and fisheye photograph. In order to verify an accuracy of tree height, it was compared with a ground measurement for the total number of trees and the histogram of tree height. Although the total number of trees measured by the laser scanner was smaller than measured by the ground measurement, good coincidence was obtained by the tall trees higher than 20m which have a large number in this site. In order to verify the profile of PAD, the measurement by the plant canopy analyzer (LAI-2000, Li-Cor) was conducted on each floor of the tower. A clear distinction of canopy space and trunk space, and PAD in the layer higher than 20 m was seen in the measurement by the laser scanner, but these were not seen in the measurement by the plant canopy analyzer. These results indicated that the laser scanner was suitable for the measurement of PAD rather than the plant canopy analyzer.

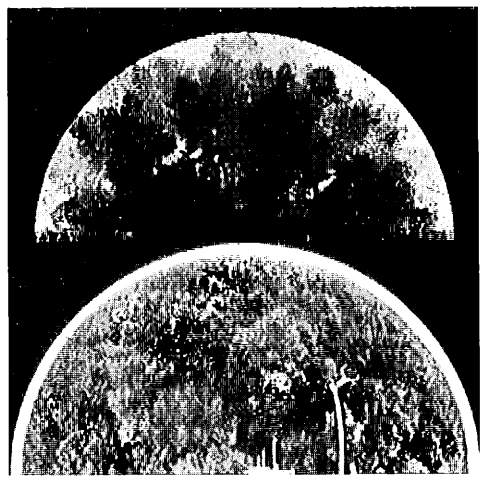

Fig. 2 Distance image measured by laser scanner (upper) and fisheye photograph (lower).

Reference

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P61

THE RESPONSE OF TROPICAL FOREST PHOTOSYNTHESIS TO SEASONAL VARIATIONS IN LIGHT CONDITIONS IN THE AMAZON REGION

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This study examines radiation-related factors associated with seasonal and interannual variation in model-simulated gross photosynthesis of tropical evergreen broadleaf forest in the Amazon region. An 11-year climatology is produced for photosynthetically active radiation (PAR), canopy-absorbed PAR, and model-estimated gross photosynthesis. A sun-shade model of canopy photosynthesis was employed to simulate mid-day rates of gross photosynthesis. The analysis was performed on both regional and local scales. Previous studies have demonstrated that the PAR regime influences photosynthesis directly by affecting (a) the total energy available for photosynthesis (via total PAR), (b) the spatial distribution of PAR within the canopy (via diffuse PAR), and (c) the spectral composition of diffuse PAR. Factors (b) and (c) directly influence photosynthetic rates through their effect on canopy light use efficiency. Evidence of this influence is apparent in the present analysis. The diffuse PAR fraction is a key determinant of how gross photosynthesis responds to variations in total and/or diffuse PAR. Generally, high diffuse PAR fractions indicate both sunlit and shaded leaves are light-limited, whereas low diffuse PAR fractions indicate light limitation by only shaded leaves. Among years, mid-day rates of gross photosynthesis typically exhibit positive correlations with total PAR (sum of direct and diffuse PAR). Negative correlations with total PAR and positive correlations with diffuse PAR are observed in limited regions and months. Whereas the majority of the Amazon region exhibits high diffuse PAR fractions (>0.75) throughout the year (even during dry season), the southeastern region in particular has lower values (<0.5) on a seasonal basis. Potential changes in the Amazon PAR regime associated with climate change may be expected to directly influence rates of gross photosynthesis. These results reveal the unique spatiotemporal patterns of light limitation in the Amazon and its dependence the ambient conditions of PAR scattering and extinction by clouds. Accurate modeling and monitoring of vegetation-atmosphere carbon exchange in moist tropical forest depends in part on accounting for these conditions.

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TRACER VALIDATION OF LAGRANGIAN ANALYTICAL SOLUTION INSIDE AND ABOVE A FOREST CANOPY

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A two-dimensional Lagrangian analytical model was recently proposed to relate source strength to concentration profiles within and above a plant canopy. This new model is able to describe passive scalar dispersion even in conditions of local advection and permits horizontal inhomogeneity of a tracer field. This new approach appears to be a significant step forward in canopy diffusion modeling, relying on gradient-diffusion relationships and horizontal homogeneity. This new model, therefore, has broad application areas such as flux and concentration footprint estimation and stable isotope modeling inside a plant canopy.

A thorough validation in real outdoor conditions is essential and the present work is an extension of preliminary validations done with wind tunnel experiments and incomplete data set in the field. The paucity of suitable experimental data in natural vegetation canopies has hindered us from improving the model and extension to other applications. In this respect, a tracer experiment can provide us with a powerful tool to evaluate the performance of the Lagrangian model. Tracer concentration profiles were measured inside and above a managed pine forest at the Florida AmeriFlux site in 2004 and 2006. During this experiment, several passive tracers were released at two different levels from a line source and tracers concentrations measured at ten levels above the surface.

This poster reports on profiles of turbulence statistics measured with three-dimensional sonic anemometers and discusses the sensitivity of the Lagrangian analytical model to the various turbulence scales used and their impact against these turbulence scales on the profiles of concentrations measured inside and above a forest canopy for a variety of environmental conditions.

Acknowledgements *This study is supported by the U.S. Dept. of Energy, Office of Biological and Environmental Research, Terrestrial Carbon Processes Program.*

P63

SURFACE FLUX PARAMETERIZATION SCHEMES FOR BARE SOIL SURFACES: PHYSICS AND SCHEME EVALUATION

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Bare soil is a major landscape in arid and semi-arid regions. Heat flux parameterization schemes for bare soil surfaces play a crucial role in modeling land-atmosphere interactions in this region and they are also a basis for developing sparse-canopy heat transfer schemes. This paper presents relationships of thermal roughness lengths (z_{0h}) with aerodynamic roughness lengths (z_{0m}) and flow state for eight aerodynamically rough bare soil surfaces in arid and semi-arid regions. These sites represent a variety of conditions of surface roughness lengths (0.5 mm ~ 10 mm) and sensible heat fluxes (–50 W m^{-2} ~ 400 W m^{-2}). It is shown that z_{0h} and parameter kB^{-1} (= $\ln(z_{0m}/z_{0h})$) exhibit clear diurnal variations for each site, with higher values in the daytime and lower values in the nighttime. Mean values of kB^{-1} for the individual sites increases with z_{0m} while z_{0h} decreases with it. As a result, C_D (momentum transfer coefficient) increases faster than C_H (heat transfer coefficient) with the surface roughness length. Parameter kB^{-1} often becomes negative at night for moderately rough surfaces (z_{0m} ~ 1 mm) and even in the daytime for relatively smooth surfaces (z_{0m} < 1 mm). This indicates that the widely accepted excess resistance for heat transfer can be negative, which cannot be explained by current theories for aerodynamically rough surfaces. Further analysis shows that the diurnal variations of z_{0h} depend on the flow state, because $\ln(z_{0h})$ is most correlated with $u_*^{1/2}|T_*|^{1/4}$, though not strongly for smooth surfaces (z_{0m} < 1 mm). Based on these results, we evaluated performances of five kB^{-1} schemes at these bare soil surfaces. We identified one scheme that has an overall better performance and is able to reliably estimate surface turbulent fluxes at all the sites, while other schemes of interest may systematically over-estimate or under-estimate heat fluxes at some sites or have a limited applicable range. The different performances result from how well a scheme can produce the major characteristics of heat transfer over bare soil surfaces.

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SCALING CARBON DIOXIDE AND WATER VAPOR EXCHANGE FROM LEAF TO CANOPY IN A LOWLAND DIPTEROCARP FOREST

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The exchange of both carbon dioxide and water vapor by terrestrial ecosystems affects global warming and plays an indirect role in the regulation of the surface temperature of the planet. Tropical rain forest, in particular, plays an important role in climate change because of their large plant volume and complexity. Since the gas-exchanges in a forest are related to various complicated physical and physiological processes and factors interactively, more precisely analyses based on an individual leaf studies linked to other processes, including light and rainfall interception, scalar and energy transfer, soil respiration process are needed. In order to understand how interactions between environmental factors and leaf-level physiological parameters might impact a canopy-level CO_2 exchange, we developed and parameterize a multi-layer forest model in a tropical lowland dipterocarp forest in Peninsular Malaysia.

Observations were conducted at the Pasoh Forest Reserve where is about 70 km southeast of Kuala Lumpur, Peninsular Malaysia (2°58' N, 102°18' E). The core area (600 ha) of the reserve is a primary lowland mixed dipterocarp forest, consisting of various species of *Shorea* and *Dipterocarpus*. The continuous canopy height is approximately 35 m, although some emergent trees exceed 45 m. In order to parameterize a leaf submodel of the forest model, we measured gas-exchange characteristics at the scale of a leaf using a leaf chamber and at the scale of a whole forest by eddy covariance method. We scale from leaf level gas exchange to a canopy using the information of a canopy structure, such as a profile of leaf area index, a distribution of leaf inclination angle, clumping index.

Leaves in the canopy of the Pasoh Forest Reserve showed patchy stomatal behavior, and the results indicated that the afternoon depression in apparent photosynthetic capacity in dipterocarp leaves was mainly caused by patchy stomatal closure. Apparent photosynthetic capacity at the scale of a single leaf was modeled and scaled with cumulative leaf area index to a canopy. The diurnal patterns of energy, H_2O and CO_2 fluxes above the canopy were investigated using the multi-layer model that considered patchy stomatal closure. Both bimodal and homogeneous stomatal opening distributions were simulated, and the results indicated that the observed negative relationship between CO_2 absorption under light-saturated conditions and vapor pressure deficit were not sufficiently explained by stomatal closure alone, for homogeneous stomatal opening distributions. For bimodal stomatal opening distributions, however, a greater depression in canopy photosynthesis was found with increased atmospheric vapor pressure deficit. The diurnal changes in CO_2 flux accumulated until each layer indicated the afternoon depression in canopy photosynthesis, which was almost completely explained by the assimilation depression of leaves above >30 m in the canopy that was caused by bimodal stomatal closure, although the assimilation of lower leaves was not limited by bimodal stomatal closure. We concluded that the diurnal change in NEE at the Pasoh Forest Reserve could be accurately explained with the modified multi-layer model by considering patchy stomatal closure. Thus, the midday depression in canopy photosynthesis was mainly caused by patchy stomatal closure.

P65

GPP DYNAMICS OF AN OLD-GROWTH CHINESE MIXED FOREST: SCALED BY VPM MODEL

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Remote sensing techniques provide ideal tools to validate and scale up flux measurements of single tower. In this paper, a satellite-based Vegetation Photosynthesis Model (VPM) was applied to simulate the annual and seasonal dynamics of GPP fluxes of a old-growth Chinese mixed forest. The VPM model uses two improved vegetation indices(Enhanced Vegetation Index (EVI), Land Surface Water Index (LSWI)). We used there years (2003-2005) images from the MODIS sensors and CO_2 fluxes data form a flux tower site in Changbai Mountain, Jilin Province,China.

Fluxes were measured using micro meteorological methods and routine correction were applied to fluxes time series. Neural network technique was used to fill gaps in the hourly fluxes time series and to predicate daytime RE.

The predicted GPP values agreed reasonably well with the GPP estimated from the measured NEE time series. This study highlighted the biophysical performance of improved vegetation indexes in relation to GPP and demonstrated the potential of the VPM model for scaling-up of GPP although some improvements are needed.

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MODEL VALIDATION OF NET ECOSYSTEM CO_2 EXCHANGE AT ASIAFLUX SITES: TOWARD CARBON BUDGET IN EAST ASIA

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Process-based carbon cycle models are an essential tool for carbon budget studies to interpret and integrate observational data and to extrapolation them for time and space. Therefore, validation of the models used in regional carbon budgeting is an important task, which determines the credibility of estimation.

We have developed a process-based terrestrial ecosystem carbon cycle model, on the basis of a simple model (Sim-CYCLE; Ito and Oikawa, 2002), for the purpose of evaluation of East Asian carbon budget, in conjunction with various observational data. The modified model consists of four sectors (Fig. 1), canopy trees, floor shrubs and grasses, dead biomass, and mineral soil, each of which is sub-divided into a couple of functionally different components. The model simulates specific carbon flows among the atmospheric CO_2 and ecosystem carbon pools: photosynthetic assimilation (gross primary production, GPP), allocation, plant autotrophic respiration (AR), litter fall, and soil microbial heterotrophic respiration (HR). The ecosystem carbon budget (net ecosystem production, NEP) is obtained as NEP = GPP – AR – HR, and the difference in environmental responsiveness of the carbon flows produces complicated spatial and temporal variations. Ecophysiological parameters used in the model were mainly obtained through calibration using observational data of the ecosystem surveys such as plant biomass, soil organic matter, litter fall, and net primary production. Additionally, the model was improved by introducing advanced canopy radiation transfer and biochemical photosynthetic schemes, which operates at 30-minute time step. For deciduous broad-leaved forest, important leaf properties such as maximum carboxylation rate and leaf mass per area were parameterized using field studies to account for leaf aging and acclimation.

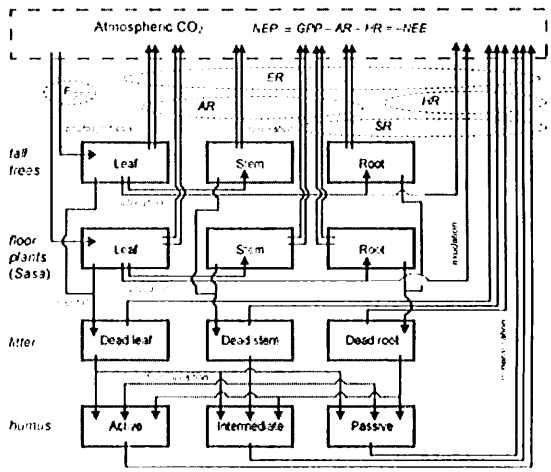

Fig 1. Model structure.

Flux measurements of net ecosystem CO_2 exchange (NEE) by the eddy covariance method provide invaluable data for validation of NEP (= –NEE) estimated by the model. For the carbon budget in East Asia, data from the tower network of AsiaFlux are available at approximately 20 sites (and about 10 sites in Southeast Asia and North America). The model was firstly applied to a cool-temperate deciduous broad-leaved forest in Takayama, central Japan, where we can use the longest record of NEE from 1998 to 2005. The model simulation was driven by daily meteorological dataset of the NCEP/NCAR reanalysis from 1948 to 2005 corrected by station data. The model simulated NEP shows, in general, a good agreement with observed NEE, implying the credibility of model simulation. Clear seasonal variation in CO_2 exchange of the temperate deciduous forest was appropriately captured. However, the model simulation differed significantly from the flux data; for example, the model simulated largely higher carbon uptake in the late growing season in 2004, probably due to unexpected defoliation by tropical cyclone (typhoon). Also, the model simulated higher ecosystem respiration in non-growing times such as winter dormancy and nighttime; this may be caused by both observational and modeling reasons of atmospheric stability and snow-pack effect.

Now, we are trying to apply the model to other AsiaFlux sites such as evergreen needle-leaf forest in Fuji-Yoshida, deciduous needle-leaf forest in Tomakomai, and alpine meadow in Qinghai-Tibetan Plateau, in order to examine model applicability to a wide variety of ecosystems. The model validation using AsiaFlux data will improve the reliability of our evaluation of East Asian carbon budget.

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DEVELOPMENT OF A PROCESS-BASED MODEL FOR ANALYZING THE LAND-ATMOSPHERE EXCHANGE OF CO_2, CH_4, AND N_2O: PLOT-SCALE STUDY IN COMPARISON BETWEEN A TEMPERATE DECIDUOUS FOREST AND A TEMPERATE CONIFEROUS FOREST IN CENTRAL JAPAN

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Land-atmosphere exchange of greenhouse gases can exert considerable feedback effects on the human-induced climatic change. However, there remain large uncertainties in our understanding and quantification of the greenhouse gas exchange, owing to complexity and heterogeneity of terrestrial ecosystems. To evaluate the global warming potential (GWP) reasonably, we should account for net budgets of major greenhouse gases, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), each of which are regulated by different biogeochemical mechanisms. We developed a process-based model of land-atmosphere exchange of the major greenhouse gases, on the basis of a carbon cycle model (Sim-CYCLE). First, methane oxidation schemes were considered for one by Potter et al. (1996) and Ridgewell et al. (1999), in which CH4 oxidation rate by soil was parameterized as functions of temperature and soil moisture. Second, schemes of nitrous oxide emission by nitrification and denitrification were considered for one by Parton et al. (1996) and Potter and Klooster (1998), in which N_2O emission rate from soil was parameterized as functions of soil inorganic nitrogen, temperature, and moisture conditions. Preliminarily, we applied the model to a cool temperate deciduous broad-leaved forest in Takayama, an AsiaFlux site in central Japan, using a time-series climate data of the NCEP/NCAR from 1948 to 2004. The land-atmosphere exchange of the greenhouse gases showed clear seasonal variations: strong net uptakes of CO_2 and CH_4 and strong N_2O emission in summer. The model estimations were compared with observations with a flux tower and soil chambers, showing fair agreements. On average during the last 10 years, the model estimated that the temperate forest net absorbed CO_2 and CH4 at rates of 804.53 g CO_2 m^{-2} yr^{-1} and 0.34 g CH_4 m^{-2} yr^{-1}, and net released N_2O at a rate of 0.02 g N_2O m^{-2} yr^{-1}, respectively. Based on the 100-year GWP of greenhouse gases in IPCC (2001), the forest was estimated to have a negative effect of GWP by 807.74 g CO_2 (equivalent) m^{-2} yr^{-1}. In our forthcoming study, after modifying the model for water and nitrogen cycles, we will apply the model to other AsiaFlux sites and estimate the Asian greenhouse gas budget. The effect of net greenhouse gas is planed to be evaluated also at a cool temperate coniferous forest in Fujiyoshida, other Asian flux sites, and to compare with Takayama site.

P68

MODELING TEMPORAL-SPATIAL WATER AND ENERGY BUDGETS IN NORTH-EASTERN SIBERIA BY LAND SURFACE MODEL

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Synthesis of river-monitoring data reveals that the average annual discharge of major arctic rivers showed upward trend. Some studies reported that the increasing trend in discharge relates in part to the winter warming and increased winter precipitation. In contrast, precipitation shows downward trends in summer season, strongest in August (Yang et al. 2002). However, evapotranspiration (ET) in arctic basin areas showed stable inter-annual trend, which seems to be related to both melt of ground ice and increased winter precipitation input. However, we do not have enough data about the relationship between vegetation and water budget in arctic area. Thus, we calculated water and energy budgets in north-eastern Siberia over 15 years using a one-dimensional land surface model (Yamazaki et al., 2004). The model, divided the canopy into two layers and then represented the fluxes above and within the canopy, was applied to north-eastern Siberia bounded by 30° - 72°N and 90° - 180°E, with grid spacing of 0.5° × 0.5°.

Precipitation shows a spatial distribution decreased gradually with latitude, while ET is spatial-largely scattered. Spatial distribution of the calculated ET is similar to the fashion of Serreze *et al.* (2003) who calculated ET in the arctic area with a climate model. Furthermore, to demonstrate the soundness of the calculated ET, ET in Lena watershed was calculated by water budget method based on the measurement of precipitation and runoff. Their comparison showed good agreement. In an ET-climate diagram, large ET did match regions of high air temperature and precipitation. The diagram also represented that the spatiality of ET was determined by air temperature rather than precipitation. ET was in significant increasing trend in the regions dominated by taiga forest and grassland over the 15 years, while air temperature showed decreasing trend over all area. The decrease of temperature seems to be correlated the seasonal trend decreasing since May, indicated in Lena watershed. Precipitation in Lena watershed showed a characteristic seasonal trend increasing at melting period and late summer. This seasonal pattern of precipitation could influence on the trend of ET increasing in summer season. The precipitation in late summer when ET is relatively small does probably contribute to runoff and soil storage, thus the water flowed into soil would be used for ET of the next year through the freezing period. Our calculation clearly showed that precipitation and ET were increasing in warm and wet area over the previous 15 years. We anticipate that this study could contribute to understand the change of water and energy fluxes in Asia continent following to climatic change.

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GROSS PRIMARY PRODUCTIVITY ESTIMATION OF DECIDUOUS BROADLEAF FOREST BY 3-PG MODEL COMPARING WITH MODIS IMAGE

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Gross Primary Production (GPP) is the assimilation of carbon absorption by plants. It can be indicated the carbon status on the biosphere which is to understand Global Warming, relating to Kyoto Protocol. To estimate GPP, there are several representative models. One of those models is 3-PG, namely Physiological Principles Prediction Growth (Landsberg and Waring, 1997). It is process based model which required the actual monthly meteorological or the mean monthly meteorological data as the main input data. All parameters in 3-PG model are recently used appropriately for Eucalyptus and Pine, but not for the deciduous broadleaf forest.

In this study, 3-PG model parameterization is done for Deciduous Broadleaf Forest to estimate Gross Primary Productivity (GPP). The flux tower data from Hitsujigaoka Site (FFPRI), Hokkaido since 2000-2003 is collected for analyzing in this study such as the meteorological data. First, the sensitivity analysis is examined among the meteorological data for checking GPP value how much it vary. From the result, it showed that the minimum and optimum temperatures are the most sensitive to GPP value. The parameterization is done based on the temperature data in terms of the temperature growth modifier. Figure 1 illustrated that the observed GPP and the estimated GPP have the relation likely approached to one to one line.

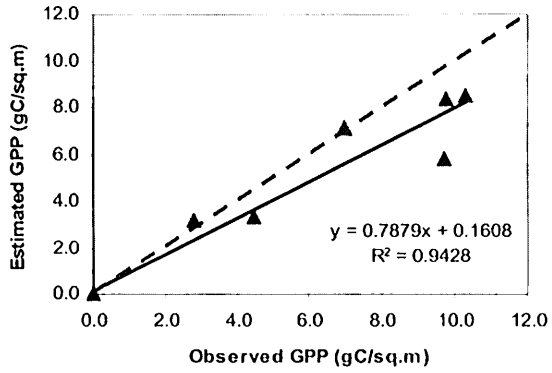

Figure 1 Comparison of observed GPP and estimated GPP, red dot line is one to one line.

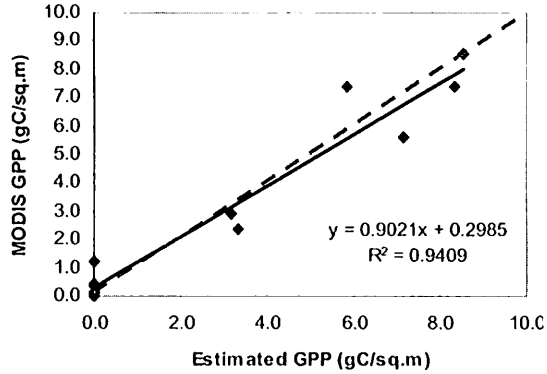

Figure 2 Comparison of estimated GPP and MODIS GPP, red dot line is one to one line.

After doing the parameterization, MODIS GPP, 8-days composite which is integrated into monthly data, is compared with the estimated GPP from 3-PG model. The comparing method is based on one pixel basis. The result is showed in the figure 2. MODIS GPP and the estimated GPP performed a very good relation which closed to one to one line. However, both estimated GPP and MODIS GPP are given the underestimated value when comparing with the observed one from the flux tower data. There is other parameters related to estimate GPP directly which is still not do the parameterization. Since the meteorological parameter is only adjusted in this study. Then, the result could be improved the accuracy appropriately.

Finally, we would like to give a special thanks to Hokkaido Research Center, Forestry and Forest Products Research Institute (FFPRI) for supporting us the flux tower data as the long time monitoring meteorological data.

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COMPARISON OF MODIS DRIVEN NET RADIATION OVER A MOUNTANOUS TERRAIN AND A HETEROGENEOUS FARMLAND

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Moderate Resolution Imaging Spectroradiometer (MODIS) senses throughout the earth nearly twice per daytime (i.e. onboard TERRA in the morning and onboard AQUA in the afternoon), and provides a powerful tool to monitor various ecosystems periodically. The main objective of this study is to validate the fully MODIS driven net radiation for both TERRA and AQUA by comparing with flux tower measurements in a heterogeneous farmland and a rugged deciduous forest for clear sky days. We described the MODIS processing covering land and atmospheric products using IDL / ENVI environment. We also tested whether MODIS successfully captures diurnal variation of required input variables for calculating net radiation. The accuracy of MODIS driven data including air temperature, humidity, and total solar radiation were compared with field data measured in national weather stations of Korea. Evaluation against field measurement showed that net radiation were retrieved with overall root mean square errors of 45 W/m^2 and 38 W/m^2 for TERRA and AQUA in the forest site, respectively. MODIS also successfully retrieved diurnal variation of air temperature, actual vapor pressure, and solar radiation with good accuracy. We also discussed the effect of complexity and heterogeneity on the estimation of net radiation.

P71

APPLICATION OF FIELD OBSERVED FLUXES AND NOAA/AVHRR TO EVALUATE SEASONAL CARBON BUDGET OF BLACK SPRUCE FORESTS OVER ALASKA

T. Kitamoto[1], M. Ueyama[2], Y. Harazono[2], T. Iwata[1], and S. Yamamoto[1]

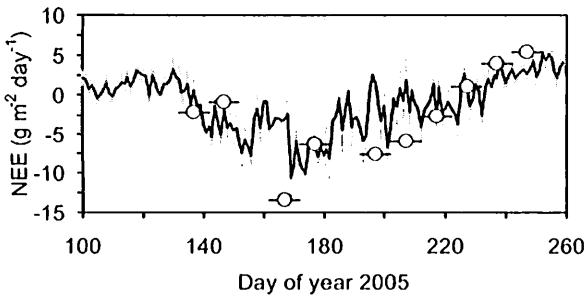
[1]Graduate School of Environmental Science, Okayama University, Japan

[2]International Arctic Research Center, University of Alaska, Fairbanks

Climate change in northern high latitudes has been remarkable in the past few decades, and the affection on the mid-latitudes climate has been revealed by regional models and synoptic analyses. Since the changes in the prolonged vegetation growing period, enhanced decomposition rate of soil organic matter, and permafrost degradation are evidently detected in arctic Alaska and Siberia, to reveal the actual changing trend of ecosystem dynamics and the carbon budget change are important to understand the climate-connection between high latitudes and mid and low latitudes.

We have been observed carbon fluxes at a sub arctic black spruce forest in interior Alaska since 2002 fall, and some controlling factors to the carbon budget were parameterized. As the black spruce forest was dominant in Alaska's boreal forests, we applied the both remote sensing and field observation data to evaluate the seasonal changes of carbon budget over all Alaska. In the analysis, we made an empirical model to calculate the carbon budget by using only satellite data of normalized differential vegetation index (NDVI) and land surface temperature (LST). The NOAA/AVHRR satellite data (10-days composite) and observed fluxes at the site in 2005 were used to determine the relationship among dataset, in which outputs of carbon budget analysis tool (CBAT) for the black spruce forests were also integrated into the model to calculate gross primary productivity (GPP), ecosystem respiration (R_{eco}) and net ecosystem exchange (NEE). The CBAT is an empirical model designed to analyze observed fluxes. Model calculations were carried out for ten periods within 2005 growing season and the calculated NEE, GPP, and R_{eco} agreed well with those measured at the observation site (NEE was shown in the Figure).

The same model parameters and AVHRR data were applied to whole Alaska area to estimate carbon budget of the ecosystem, and then maps showing spatial distribution of NEE, GPP, and R_{eco} over Alaska black spruce forests were obtained. The distributions of carbon budget showed clear regional differences in the start time of the growth and the different carbon sink. Black spruce forests were high productivity at middle-east part of interior Alaska, even though the area was extremely cold region in winter.



Seasonal change of observed NEE at the black spruce forest site in interior Alaska and calculated NEE by the empirical model with AVHRR data. Gray area represents standard deviations of 10-days.

P72

SPATIAL HETEROGENEITY OF SATELLITE-SENSED FLUX INDICES RELATED TO EVAPOTRANSPIRATION

S. Moon and J. Kim

Yonsei University, Seoul. Korea

Bridging the gap between scales is the challenge to the flux research community. For the MODIS grid scale (i.e., 7km x 7km) of the Gwangneung KoFlux site in central Korea, the scale of spatial heterogeneity is of the order of ~1 km. When we focus on upscaling or downscaling of eddy-covariance flux observations, smaller extent such as footprint scale of tower flux (e.g., 1km x 1km) is needed. We set the two study extents of 1km x 1km for the two flux towers in the Gwangneung forest catchment. In this presentation, representative structural functions such as semivariogram and fractal were used to quantify spatial heterogeneity and directional dependence (i.e., anisotropy) of ET-related variables obtained from LANDSAT ETM+ imageries and DEM over the montane landscape. The variables include topographically corrected-normalized difference vegetation index (NDVI), land surface temperature (LST), and topographic elements (i.e., elevation, slope angle and slope aspect). Our results show that these indices have anisotropy, various scales of statistical heterogeneity that are less than 1km and have fractal characteristics. Implications of these results for sampling strategy, grid scales of ecohydrological modeling, and satellite image analyses are discussed.

P73

UTILITY OF SPECTRAL VEGETATION INDEX FOR ESTIMATION OF LIGHT USE EFFICIENCY IN ARTIFICIAL FORESTS OF JAPANESE LARCH AND HINOKI CYPRESS IN JAPAN

T. Nakaji [1], R. Ide[1], K. Takagi[2], Y. Kosugi[3], S. Okubo[3], K. Nishida[4], N. Saigusa[5] and H. Oguma[1]

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To clarify the utility of spectral vegetation index (VI) for estimating light use efficiency (LUE) of artificial coniferous forests, we investigated the seasonal variations of canopy spectral reflectance and CO_2 flux in young and mature Japanese larch (*Larix kaempferi*) forests and mature hinoki cypress (*Chamaecyparis obtusa*) forest. In this study, we conducted regression analysis between LUE and eight VIs (NDVI, EVI, GEMI, SAVI, PRI, CCI, CI, mND_{705}) derived from spectral reflectance.

All measurements were carried out in 3 Asia Flux monitoring sites; Kiryu (hinoki cypress), Teshio CC-LaG site (young larch) and Tomakomai (mature larch) in Japan (http://www-cger2.nies.go.jp/asiaflux/index.html). In each forest, downward and upward spectral radiance between 300 and 1100 nm was measured with hemispherical spectroradiometers mounted at the top of flux tower, and the spectral reflectance of forest canopy was derived from their ratio. We calculated mean VIs around noon (11:00-13:00 JST) based on the 1-min reflectance data recorded under clear sky (defined as relative irradiance >75% of full sunlight). The ideal maximum irradiance at the ground surface (i.e. full sunlight) was estimated from the sun position and atmospheric conditions.

LUE was calculated as gross CO_2 flux (FCO_2) divided by the absorbed PAR (APAR). FCO_2 was calculated from canopy CO_2 flux which was measured using a closed-path eddy covariance system and CO_2 storage estimated from temporal changes of CO_2 concentration. Daytime ecosystem respiration was estimated from an exponential relationship between air temperature and nighttime ecosystem respiration. Since the transmitted PAR through the canopy was not fully investigated during the experimental periods, APAR was calculated as the difference of incoming PAR and reflected PAR from canopy surface.

In the case of mature larch forest, all the calculated VIs significantly correlated with daily mean LUE ($P < 0.001$, Figure 1). Although the most relationships of LUE and VIs tended to be saturated at the high range VI, CCI and LUE showed good linear relationship with highest correlation coefficient. In this presentation, we summarize the results of regression analysis in each forest site, and discuss the effects of species type and tree age on VI usefulness.

Table 1. Listing of VIs used in this study. R_λ and D_λ indicate reflectance value and first derivative of reflectance at wavelength of λ nm, respectively.

Index	Formulation
NDVI	$(R_{857}-R_{647})/(R_{857}+R_{647})$
EVI	$((R_{857}-R_{647})/(1+R_{857}+6R_{647}-7.5R_{466}))\times 2.5$
GEMI	$eta\times(1-0.25\,eta)-(R_{647}-0.125)/(1-R_{647})$
	$eta = (2\times(R_{857}-R_{647})+1.5\,R_{857}+0.5\,R_{647})/(R_{857}+R_{647}+0.5)$
SAVI	$((R_{857}-R_{647})/(R_{857}+R_{647}+0.5))\times 1.5$
PRI	$(R_{531}-R_{570})/(R_{531}+R_{570})$
CCI	D_{720}/D_{700}
CI	$(R_{750}-R_{705})/(R_{750}+R_{705})$
mND705	$(R_{750}-R_{705})/(R_{750}+R_{705}-2R_{445})$

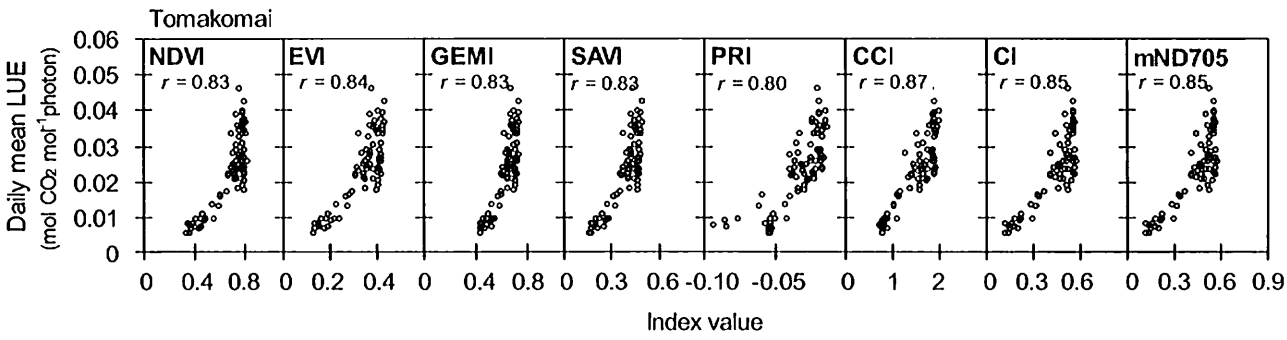

Figure 1. Relationship between VIs and daily mean LUE in Tomakomai larch forest ($n = 78$).

P75

ESTABLISHING A NETWORK OF EXISTING FLUX SITES IN THAILAND

S. Boonyawat[1], S. Thanisawanyangura[1], S. Pookngam[1], C. Tantasirin[1], P. BoonTham[1], P. Thongdeenorg[1], S. Panuthai[2], A. Chidthaisong[3] and P. Kasemsap[1]

[1] *Kasetsart University, Bangkok. Thailand*

[2] *National Park, Wildlife and Plant Conservation Department, Bangkok, Thailand*

[3] *King Mongkut's University of Technology Thonburi, Bangkok, Thailand*

Several observation sites have been established to study flux of gas and energy in diverse ecological systems in Thailand since 1994. While the observations in a few sites, mainly in the south of Thailand, have been terminated due to various reasons, researches in many other sites continue until now. Existing flux observation sites in Thailand are located in natural forests, tree plantations and cultivated field crop plantations all over the country.

Total forest area in Thailand was estimated at approximately 12.5 million hectare which is equivalent to 25% of total land in Thailand. Several observation sites were set up to study flux in major types of forest. An observation site at Sakaerat is dedicated to study CO_2, water vapor and heat exchange in dry evergreen forest. Another observation site at Maeklong was established to study the meteorological and biological influence on CO_2 concentration and flux in the mixed deciduous forest. Researches at Kog-Ma watershed focus on hydro-meteorological studies on hill evergreen forests (lauro-fagaceous forests) which are wide spread throughout Southeast Asia in mountainous area at elevation greater than 1,000 m. In addition, two new flux sites are planned to be set up at the beginning of 2007. One will be at the third generation dry dipterocarp forest at Ratchaburi province and another will be at a climax dry dipterocarp forest in Sakol Nakon province.

There are two existing observation sites in economically important tree plantations. One is located in a teak (*Tectona grandis*) plantation in Lampang province. The initial objectives were to observe and to model the hydrologic cycle and energy fluxes. The other is located in a rubber (*Hevea brasilensis*) plantation in Chachoengsao province. The aims are to study carbon, water, and energy budget in the plantation ecosystem. Rubber plantation in Thailand now covers more than 2.5 million hectares.

Rice is the most important field crop in Thailand. Growing area exceeds 10 million hectares annually. One observation site is in rain-fed paddy field in Sukhothai province and the other site is in irrigated paddy field in Pitsanulok province. There is also an observation site in a cassava field in Nakorn Ratchasima province. Cassava planning area averages more than 1 million hectares. These sites in field crop plantations were established in the Global Energy and Water Cycle Experiment.

Most of these observation sites were established through collaborations with and/or assistances from many scientists from international institutes and agencies, mainly from Japan (National Institute of Advanced Industrial Science and Technology, Tokyo University of Information Studies, Tokyo University of Agriculture and Technology, etc.) and France (Centre de coopération internationale en recherche agronomique pour le développement and French National Institute for Agricultural Research).

With the encouragement from AsiaFlux, several principal researchers of these existing observation sites in Thailand convened on September 13, 2006 and unanimously agreed to establish a network of existing observation sites in Thailand. The initial objectives of this network will be (1) to promote collaboration among researchers (2) to promote information exchange, (3) to organize scientific meeting and workshop on flux studies, (4) to organize training courses on important scientific techniques, and (5) to attempt to find research fund. Finally, the organizing committee was set up to hold the first ThaiFlux Colloquium on October 31, 2006 at Kasetsart University.

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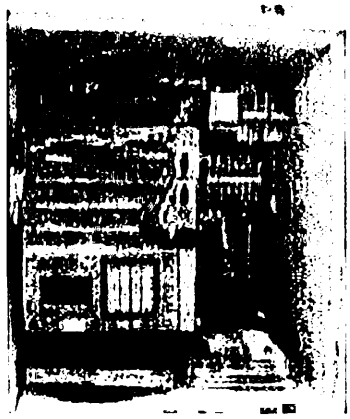
Eddy Covariance Measurement System
C-SCT-SAT/7500

SAT & CO2/H2O Analyzer



Measurement Box

Solar Power Generation Unit

Summary

This system measures the Sensible Heat, H_2O and CO_2Flux using the eddy covariance method in our data-logger. The whole system do not require the AC power. If you choose this system, you can get the Sensible Heat, H_2O and CO_2 Flux anywhere.

Measurement Method

The measurement system both Raw 10Hz data, and calculated Flux data on the data-logger memory and Memory Card(ATA/CF card) in harsh conditions. The Flux calculation is basing on real-time each variance and covariance data, air density and specific heat at constant pressure.

Measurement Items (standard)

1. 3-axis wind component(Ux, Uy, Uz), Sonic Temperature (10Hz fluctuations)
2. CO_2, H_2O 10Hz fluctuation
3. Air Temperature and Relative Humidity
4. Short-wave and Long-wave Radiation component(4 types)
5. Air Pressure

System Customize

We prepare various kind of sensors.
For Example:
Wind Speed profile, Air Temperature & Relative Humidity profiles, Soil Heat Flux, Soil Water Content and Soil Temperature and Soil Respiration.

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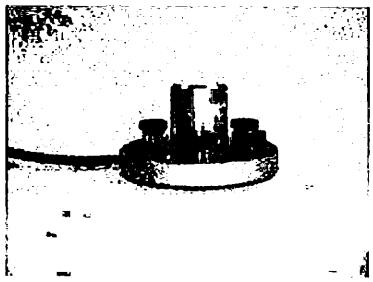
Climatec

Portable Pyrheliometer PCM-01

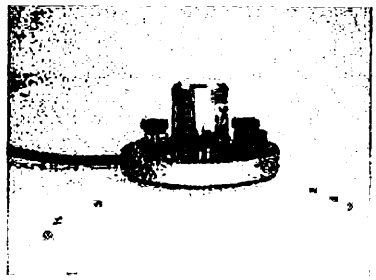


This Pyreheriometer observes solar irradiance. The sensor is thermopile.
It's used by micrometeorologic.
It's easy to use, light and no power.

Specification

Spectral range	315-2800nm
Sensitivity	7mV(kW·m^{-2})
Response time	1sec
Accuracy	±3%
Dimension	φ85×45mm
Weight	0.5kg
Cable	10m

Light Photon Senser PAR-01

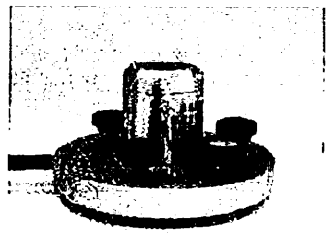


It's instrument for measuring photon's quantum of solar spectrum (400-700nm).
The sensor is Siliconphotodiode.

Specification

Spectral range	400-700nm
Sensor	Silicon Photodiode
Sensitivity	0-3,000 μ Mol·m^{-2} / 0-10mV
Dimension	φ85×45mm
Weight	0.5kg
Cable	10m
Calibration	1000W typically optical source

Portable Pyrgeometer PRI-01

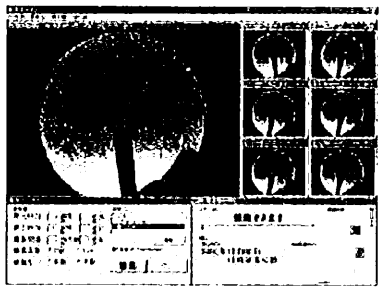


This Pyrgeometer observes infrared radiometer.
It's simplified Pyrgeometer.

Specification

Spectral range	600-1400nm
Sensitivity	5-20mV(kW·m^{-2})
Thermopile putput range	-250-+250 W/m^2
Response time	<100msec
Accuracy	±3%
Temperature sensor	Pt100Ω
Dimension	φ85×45mm
Weight	0.75kg
Cable	10m

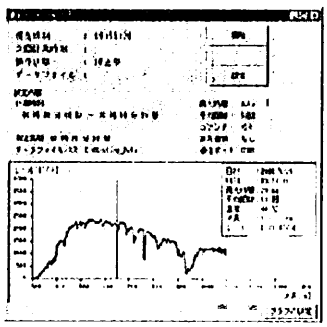
Sky View PSV-100



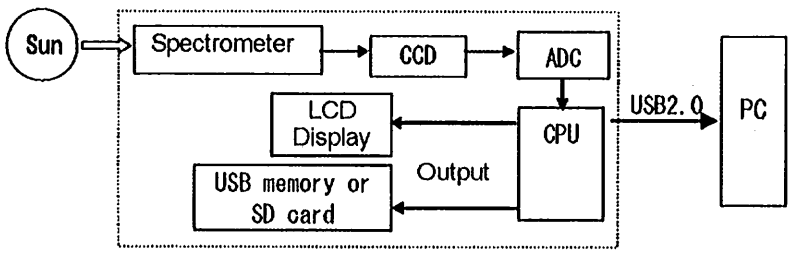
This instrument monitores of the sky by CCD camera and automatically saves a photo to JPEG format in PC for a fixed interval.
It's outdoor-safe.

System
It needs PC of Windows XP with two serial ports of RS232C, memory over 64MB and Hard disk space over 10GB.

Portable Grating Sunphotometer PPGS-100



This instrument is portable grating sunphotometer.
Spectral range is 350–1050nm, wavelength resolution is 0.4nm.
It's recorded by USB memory or SD card, so it's possible to measure without PC but also use by PC.
It's able to check measurements by LC Display.
There is optional Software.



Specification

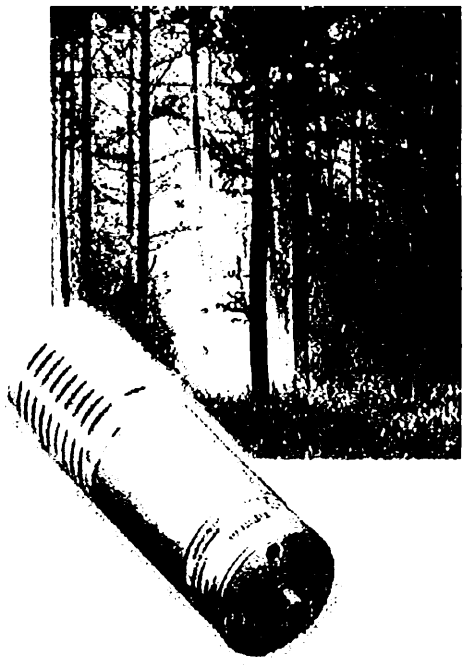
Spectrometer	Fastie-Ebert Mount
Slit width	100 μ m
Wave length resolution	0.4nm
Wave length accuracy	±0.5nm
Wave length range	350-1050nm
Optical resolution	3.6nm
Detector	SI-CCD 2048ch
Exposure time	5ms
Interface	USB2.0
Power supply	AC or AA Battery×6
Dimension	230×110×80mm 2.2kg
Record	USB memory or SD card

PREDE CO.,LTD.

Original products, Kipp & Zonen, Gill, Met One etc
Sasamoto bldg 1-26-8 Kamidaira Fussa-shi Tokyo 197-0012 Japan
TEL +81-(0)42-539-3755 FAX +81-(0)42-539-3757
URL : http://www.prede.com/ E-Mail : prede@gb3.so-net.ne.jp

GMP343 Carbon Dioxide Probe for CO2 Soil Respiration

The CO_2 respiration from soil is a good indicator of overall biological activity of the soil, and is often used when studying the carbon cycle. The CO_2 flux can be measured on the soil surface in respiration chambers. Belowground CO_2 profile measurements can be made at variable depths in the soil.

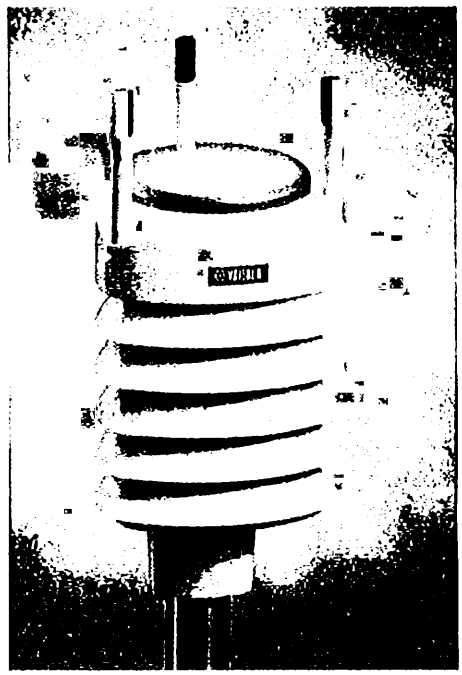


Performance

Sensor	Vaisala CARBOCAP®
Measuring principle	Single-Beam Dual-Wavelength NDIR
Measurement range options	0... 1000ppm, 0... 2000ppm, 0... 3000ppm, 0... 4000ppm, 0... 5000ppm (reduced accuracy >4000 ppm)
Accuracy	After factory calibration with 0.5 % gases ± 2.5 % of reading at the CO2 calibration points ± 1.5 % of reading
Operating environment	Temperature : -40... +60°C, Relative humidity : 0... 100%rh
Outputs	Analog outputs 4... 20mA, 0... 2.5V, 0... 5V Digital outputs RS-232, RS-485
Operating voltage	10... 36VDC
Dimensions	Length: 180 mm, Diameter: 55 mm Weight: 360g

WXT510 Weather Multi-Sensor

Integrates the six most essential weather parameters in one instrument: wind speed and direction, liquid precipitation, barometric pressure, temperature and relative humidity. Unique design with no moving parts makes it virtually maintenance free.



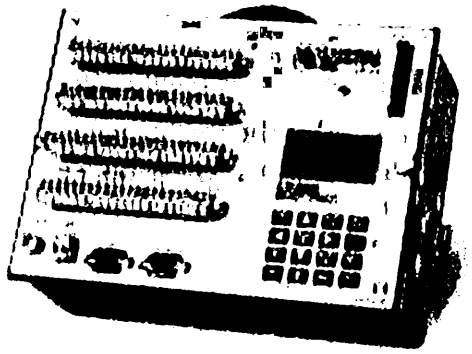
Technical Data

Wind Speed	Range : 0... 60 m/s
Wind Direction	Azimuth: 0... 360°
Barometric Pressure	Range : 600... 1100 hPa
Air temperature	Range : -52... 60 °C
Relative humidity	Range : 0... 100 %rh
Rainfall - quantity	Surface area measured: 60 cm2
Rainfall-duration	counting each ten second increment whenever droplet detected
Rainfall-intensity	Range : 0 to 200 mm/h
Operating Voltage	5...30 VDC
Dimensions	Height: 240 mm, Diameter: 120 mm Weight: 620 g

SANKO TSUSHO CO., LTD.

TEL:+81-3-5777-3627 FAX:+81-3-5777-3629

E-mail: sales@sankotsusho.co.jp URL: http://www.sankotsusho.co.jp



CR3000

Micrologger®

Features

- Program execution rate of up to 100 Hz
- 16-bit analog to digital conversions
- 16-bit microcontroller with 32-bit internal CPU architecture
- Temperature compensated real-time clock
- Background system calibration for accurate measurements over time and temperature changes
- Gas Discharge Tube (GDT) protected inputs
- Data values stored in tables with a time stamp and record number
- 4 Mbytes data storage memory
- Battery-backed SRAM and clock that ensure data, programs, and accurate time are maintained while the CR3000 is disconnected from its main power source
- Measures SDI-12 or serial sensors with four independent COM ports

CAMPBELL® SCIENTIFIC, INC.

WHEN MEASUREMENTS MATTER

Japan is Served By: Taiyo Keiki Co., Ltd.

TWC TOKYO

URL: http://www.taiyokeiki.co.jp/
E-Mail: campbell@taiyokeiki.co.jp
Urbano Bldg. Sakae 5,8-A 1-2-6 Yotsuya, Shinjuku, Tokyo 160-0004 Japan

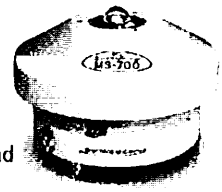
EKO INSTRUMENTS CO., LTD.

Precision instruments for accurate flux measurements

Grating Spectroradiometers

MS-710 (Visible to NIR, 350-1050 nm) **NEW MODEL**
MS-712 (NIR, 900-1700 nm)

- Precision optics in a weather proof enclosure
- Continuous field measurements
- NIST traceable
- Measurement results are displayed and stored on a PC.



Hand held Grating Spectroradiometer

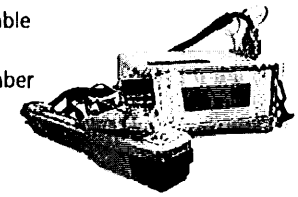
MS-720 (350-1050 nm)

- Portable
- Selectable aperture angle
- Measurement without PC
- Stores up to 800 data
- Acquisition of spectral radiation data ($W \cdot m^{-2} \cdot \mu m^{-1}$)
- Lightweight (720g, batteries included)

Intelligent Portable Photosynthesis System

LCpro+

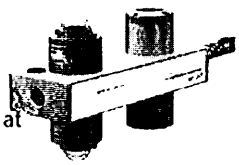
- Full and automatic programmable environmental control
- Miniaturized IRGA in leaf chamber
- Graphic display
- Powerful yet affordable



Four Component Radiometer

MR-50 (Pyranometers + Pyrgeometers)

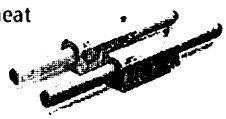
- Intension for the analysis of the radiation balance of solar and far infrared radiation.
- Measurement of Net (total) Radiation at the earth's surface



Surface Layer Scintillometer

SLS 20

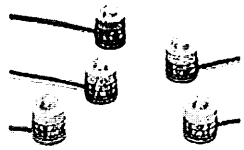
- The Ultimate sensor for turbulence, heat flux, momentum flux and crosswind
- Two parallel laser beams
- Path length : from 50 to 250m



Photon Sensor

ML-020P

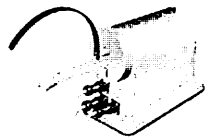
- Special designed corrector for excellent cosine response
- Measurement the photosynthetic photon flux density



Automated Shadow Band

NEW MODEL

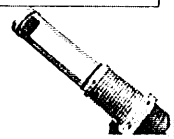
- Measurement and calculates direct, diffuse and global components of solar irradiance in each scanning



Open path CO_2/ H_2O Analyser

OP-2

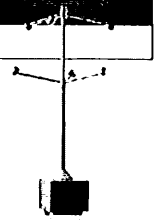
- OP-2 has longer path length (80cm) to achieve higher resolution.



3D Ultrasonic Anemometer

USA-1

- USA-1 measures accurate wind and turbulence with solid-state 3D sensor.



High Precision Pyranometer

MS-802

- ISO Secondary Standard
- WRR traceable
- Accurate measurement of global solar radiation

Heat Flow Sensor

MF-180M

- Durable designed sensor
- Suitable sensor for the direct measurement of soil heat flux

IQNet ISO9001 ISO14001 EKO

EKO INSTRUMENTS CO., LTD.
1-6 Sasazuka Center Bldg., 2-chome Sasazuka,Shibuya-ku Tokyo 151-0073,Japan
PHONE: 81-3-5352-2913 FAX: 81-3-5352-2917
http://www.eko.co.jp E-mail: info@eko.co.jp

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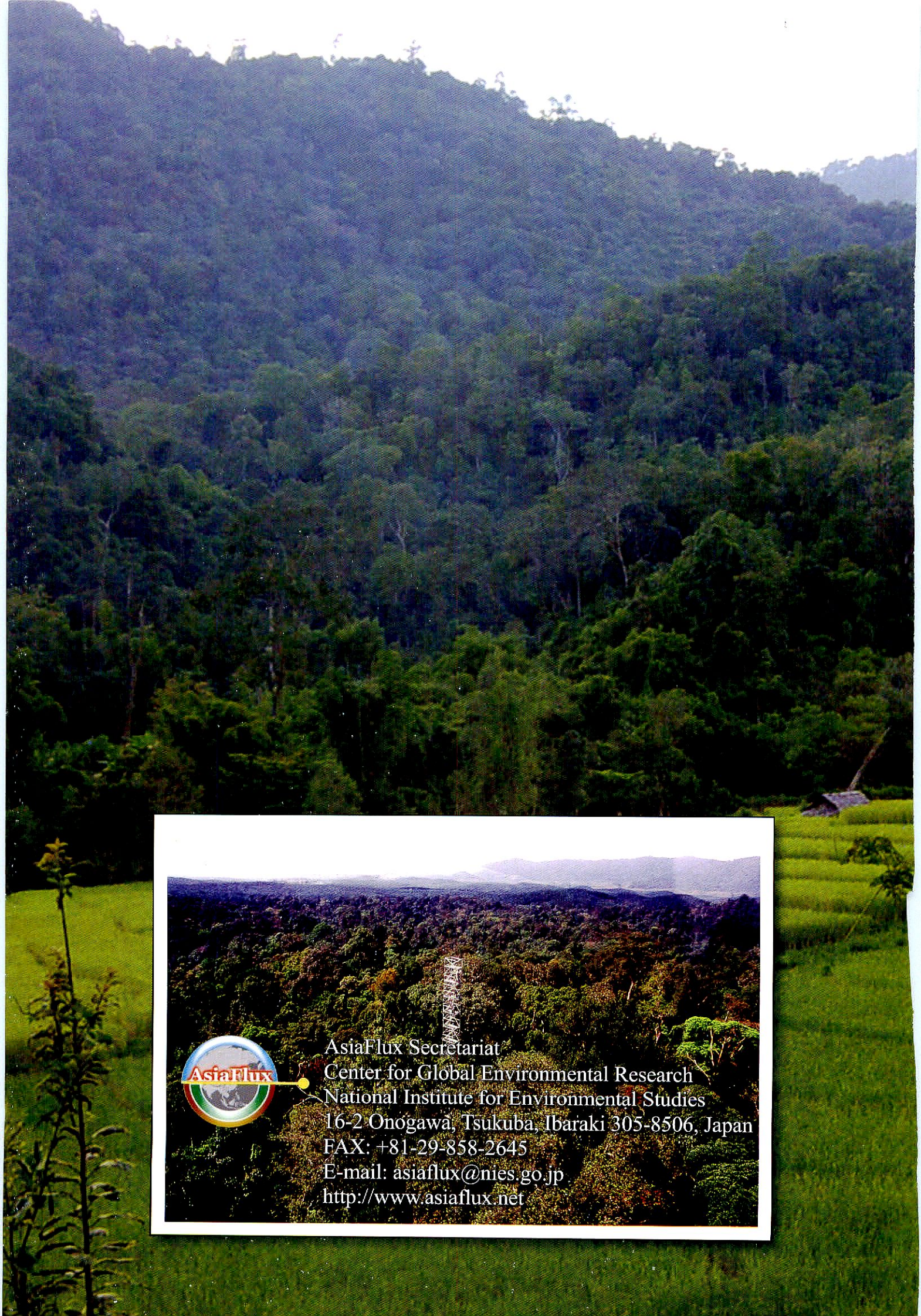

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