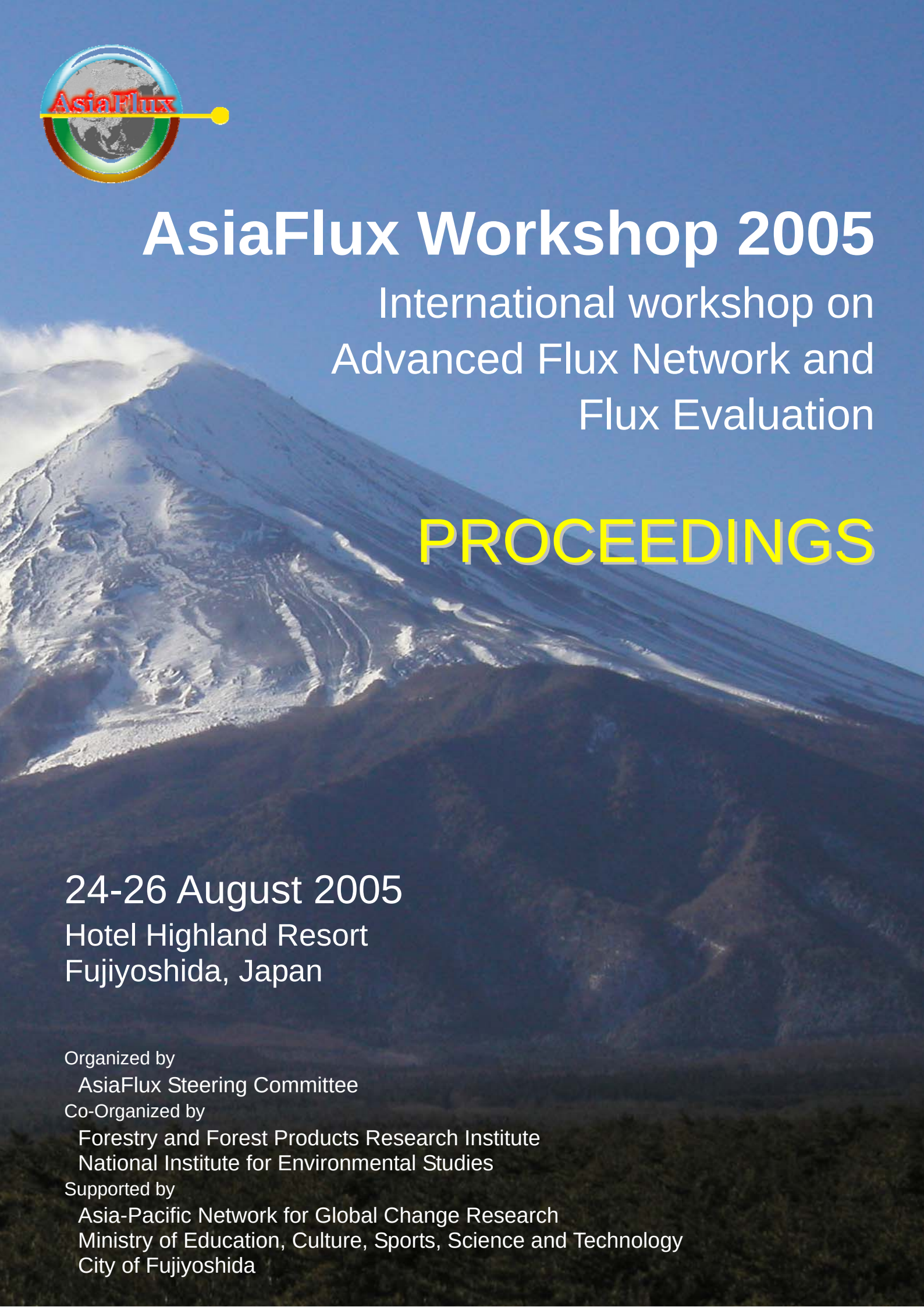

AsiaFlux Workshop 2005

International workshop on Advanced Flux Network and Flux Evaluation

PROCEEDINGS

24-26 August 2005

Hotel Highland Resort
Fujiyoshida, Japan

Organized by
AsiaFlux Steering Committee

Co-Organized by
Forestry and Forest Products Research Institute
National Institute for Environmental Studies

Supported by
Asia-Pacific Network for Global Change Research
Ministry of Education, Culture, Sports, Science and Technology
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Oral Session

S01

PRESENT SITUATION AND CHALLENGES OF ASIAFLUX - IMPLEMENTATION OF NEW PROGRAMS -

Y. Ohtani[1], J. Kim[2], A. Miyata[3], N. Saigusa[4], Y. Fujinuma[5], S. Yamamoto[6] and G. Inoue[5]
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Since the establishment of AsiaFlux in 2000, we have hosted three international workshops for the advancement of a flux measurement network in Asia. We have also published a booklet on flux observations and analyses as well as 14 volumes of the AsiaFlux Newsletter to promote the exchange of information on terrestrial carbon balance studies mainly in East and South-East Asia. AsiaFlux is now in the process of developing new programs with financial support from two distinct projects: "Initiation of the next-generation AsiaFlux" by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) and "Standardization and Systematization of Carbon-Budget Observation in Asian Terrestrial Ecosystems Based on AsiaFlux Framework" by the Asia-Pacific Network for Global Change Research (APN).

There are three main objectives for the MEXT project: 1) to offer training courses for flux measurements and analyses to scientists in Asia, 2) to develop a standardized portable flux observation system and flux analysis techniques for inter-comparing flux measurements among the AsiaFlux sites, and 3) to establish a structure for sharing and exchanging data within and outside the Asiaflux community. The aim of the training courses is to help scientists maintain their local flux observational sites and effectively analyze data. Use of the portable flux observational system and development of standardized analysis techniques will improve data accuracy. Collaborative flux observations will also be made in one or two terrestrial ecosystems in Asia within the MEXT project framework. The financial support from the APN project will be spent to host workshops and to prepare manuals for the training courses offered with the funding from the MEXT project.

Improved organization of AsiaFlux is considered important to effectively implement the above-mentioned programs. For this purpose, we are planning to establish workgroups within the AsiaFlux organization. With the support from the steering and executive committees, each workgroup takes an active part for implementing these new programs. We believe the efforts made through the MEXT and APN projects will enhance research collaboration among Asian nations and reinforce the existing framework for research cooperation among AsiaFlux, KoFlux and the Chinese flux community, with the collaboration from OzFlux.

Revision of the AsiaFlux Organization (tentative)

AsiaFlux Steering Committee
AsiaFlux Executive Committee
AsiaFlux Secretariat
AsiaFlux Workgroups (WG) and Sub-Workgroups (SWG) (New)
- AsiaFlux General WG
  - AsiaFlux Network Management SWG (e.g. Updating AsiaFlux directory and web page)
  - AsiaFlux Editorial SWG (e.g. AsiaFlux Newsletter)
  - Workshop Management SWG (e.g. AsiaFlux Workshop)
- Measurement and Data Policy WG
  - Measurement Support and Standardization SWG (e.g. Flux measurement and analysis methodology, site planning, and inter-site comparison)
  - Database and Data Policy SWG (e.g. AsiaFlux data policy and database arrangement)
  - Short Training Courses SWG (e.g. AsiaFlux training courses for flux measurement and analysis)

S02

KOFLUX PROGRESS REPORT

J. Kim[1], B.-L. Lee[2], D. Lee[1], C. Cho[3], J. Hong[1], S. Kang[4], B. Lee[5], D. W. Lee[6], J. Lee[7], J. T. Lee[8], J. Lim[9], Y. Son[10], N. Woo[1], and J. Yun[11]

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The KoFlux Program is dedicated to understanding the fluxes of energy and matter, net ecosystem production, and water resource management in key ecosystems of Monsoon Asia. KoFlux was launched in 2001 by networking individual research sites and the limited available resources in Korea to support AsiaFlux, which builds upon the scientific initiatives of regional networks such as JapanNet, ChinaFlux, KoFlux to provide a mechanism to consolidate and leverage their scientific activities. In this way, the value of data from each site is greatly augmented and new scientific questions are further explored and answered.

During Phase I (from 2001 to 2004), the KoFlux team developed a global network (www.koflux.org), providing that KoFlux data could be collected and shared anywhere. Three of the eight flux sites have been registered as reference sites for the GEWEX's inter project, Coordinated Enhanced Observing Period (CEOP,) and the data have been submitted to the international community. During the Phase II (2004-2007), the initial eight sites have been reduced to four sites (one forest and two agricultural sites in Korean Peninsula, one prairie site in Tibet, China) due to the limited funding and human resources. Most forest and agricultural ecosystems in Korea are heterogeneous, and the application of conventional eddy covariance technique has been a difficult challenge for data collection, processing and analysis. The second phase of KoFlux ("Carbo/HydroKorea") focuses on linking flux footprint, ecohydrological models and satellite images to bridge the gaps between different scales of carbon/water exchange processes in a complex landscape.

A major difference between 1st phase of KoFlux research and its successor is the establishment of the supersite where inter-disciplinary, coordinated research efforts are conducted. The Gwangneung flux site, where a flux tower has been operated since the beginning of KoFlux and ecological and hydrological information have been monitored for more than 10 years, is selected as a representative landscape of the country and becomes the center of the inter-disciplinary researches. For this, the Gwangneung supersite is re-defined as a 7 x 7 km (MODIS) unit that includes two flux towers. Within this MODIS unit, a 3 x 3 km intensive monitoring unit is designated. The unit is further subdivided into nine 1 x 1 km basic units, comparable to the scale of MODIS grid, that become the basic component of intensive field monitoring, modeling and image analysis studies. In this progress report, we present the current status of the ongoing flux sites including some preliminary results.

Acknowledgments: KoFlux is supported by the Eco-Technopia 21 Project (Ministry of Environment) and by a grant (code:1-8-2) from Sustainable Water Resources Research Center of 21st Century Frontier Research Program (Ministries of Science and Technology & Construction and Transportation of Korea).

O11

CO_2 EXCHANGE OF A TROPICAL PEAT SWAMP FOREST IN CENTRAL KALIMANTAN

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Peatland existing in the tropics has accumulated a large amount of carbon as organic matter. Indonesia contains the largest area of tropical petland, and the petaland usually coexists with tropical peat swamp forests. Recently, however, deforestation and drainage are in progress on a large scale owing to a growing demand for timber and farmlands. In addition, the ENSO drought and its consequent large-scale fires are accelerating the devastation of the peatland. The devastation enhances the decomposition of organic matter stored in peatland, and consequently increases carbon release to the atmosphere as CO_2. This suggests that tropical peatland will be a major CO_2 source in the near future. To evaluate the CO_2 balance of tropical peatland, we have measured CO_2 flux above a tropical peat swamp forest remaining in Area B of the Mega Rice Project near Palangkaraya, Central Kalimantan, Indonesia since November 2001.

The forest is located on flat peatland between a river and channel. Water table in the forest was zonally reduced near the channel. A tower of 50 m height was constructed about 300 m inside from the northeast corner of the forest (2º 20' 41.6" S, 114º 2' 11.3" E). Dominant tree species of the forest are *Combretocarpus rotundatus*, *Cratoxylum arborescens*, *Buchanania sessifolia* and *Tetrameristra glabra* and rich shrubs grow in the trunk space. The height of the forest canopy is about 26 m. Predominant wind direction was the south (SE-SW). Fetch was longer than 1 km for the southern wind. During the dry season of 2002, between mid-August and late October, peatland fires occurred in large areas around Palangkaraya because of the ENSO drought, whereas the forest did not burn. CO_2 and energy fluxes have been measured at 41.7 m by the eddy covariance technique with a sonic anemometer-thermometer (CSAT3, CSI) and an open-path CO_2 analyzer (LI7500, Licor) facing the south. Sensor signals were recorded with a data logger (8421, HIOKI) at 10 Hz. In addition, CO_2 concentrations have been measured at six heights below the flux measuring height with a closed-path CO_2 analyzer (LI820, Licor) to calculate CO_2 storage flux (F_s). Hourly mean fluxes were calculated from the data according to the following procedures: 1) removal of noise spikes, 2) planar fit rotation, 3) covariance calculation using block average, 4) WPL correction. From CO_2 flux (F_c) and F_s, net ecosystem CO_2 exchange (NEE) was calculated (NEE = F_c + F_s). Data quality was checked by wind direction and steady state tests. In addition, a friction velocity (u^*) threshold of 0.08 m s^{-1} was applied for nighttime. Gaps of missing data were filled using empirical models; ecosystem respiration (RE) or nighttime NEE was estimated from soil moisture, and gross primary production (GPP) was estimated form photosynthetic photon flux density (PPFD).

In this area, the dry season began in May and lasted until October, judging from monthly precipitation of 100 mm. CO_2 fluxes showed seasonal variations. Typically GPP continued to become more negative from the mid rainy season until the mid dry season, and rapidly became more positive in the late dry season. On the other hand, RE continued to increase through the dry season. As a result, NEE was smallest in the mid dry season at around zero and largest in the late dry season. In total, GPP and RE were significantly more negative and positive, respectively, in the dry season than the rainy season. However, NEE showed no significant difference between two seasons. These seasonal variations of CO_2 fluxes were caused by those of PPFD, vapor pressure deficit (VPD) and water table. During the dry season, high PPFD enhanced GPP until July or August, whereas high VPD depressed it in September and October. Low water table, which reflected on low soil moisture, enhanced RE through peat decomposition because the aerobic layer of peat increased; the negative relationship between RE and soil moisture is a distinctive feature at peatland.

The annual sums of NEE, RE and GPP were 721, 3580 and -2859 in 2002, 527, 3686 and -3159 in 2003, and 356, 3583 and -3227 gC m^{-2} y^{-1} in 2004, respectively. This forest worked as a net source of CO_2 at an intensity of 535±183 gC m^{-2} y^{-1} for the atmosphere from 2002 through 2004. The source intensity was largest in 2002, an ENSO year; this was probably caused by drought and low PPFD, which was caused by dense smoke emitted through large-scale fires.

O12

A COMPARATIVE STUDY OF CARBON DIOXIDE EXCHANGE BETWEEN A MATURE AND A REGROWTH JACK PINE FORESTS AT BERMS (BOREAL ECOSYSTEM RESEARCH AND MONITORING SITES, CANADA)

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The relationship between soil moisture and ecosystem-level carbon budget was investigated for BERMS (Boreal Ecosystem Research and Monitoring Sites, http://berms.ccrp.ec.gc.ca/) sites in Saskatchewan, Canada, using eddy covariance flux measurements obtained during 2001, 2002 and 2003. The study sites were located in a mature jack pine forest (*Pinus banksiana Lamb*.) with tree age of approximately 80 years, and in a young jack pine stand characterized by a sparse low canopy. Jack pine is an evergreen coniferous species that is found on well-drained and nutrient-poor soils. It is a pioneer species that grows quickly after a natural disturbance (e.g. fire or harvesting) and thus plays an important role in ecosystem regeneration after such disturbances.

The mature jack pine forest site (referred to as the old jack pine "OJP" site, location 53^{o} 55'N, 104^{o} 41'W) was established in 1993 in the southern portion of the Canadian boreal forest as part of the Boreal Ecosystem-Atmosphere Study (BOREAS) program. Under the BERMS program, carbon dioxide, water vapor, and sensible heat flux measurements have continued since 1999, using three-dimensional sonic anemometer-thermometer and a closed-path infrared gas analyzer on a scaffold tower at 28 m above ground.

The adjacent young jack pine site (referred to as harvested jack pine site, "HJP94", 53^{o} 54'N, 104^{o} 39'W) was established in 2001 at approximately 2 km southeast of the OJP site. A mature jack pine forest was harvested (clear-cut) in 1994 over an area of approximately 30 ha, and young trees from the ages of one year to ten years have been regenerating naturally. Fluxes were measured on a tower at 5 m above the ground, using a three-dimensional sonic anemometer-thermometer and a closed-path infrared gas analyzer.

The present study focuses on the relationship of the carbon budget components with soil moisture and various other environmental factors at the OJP and HJP94 sites. Focuses are also on the effect of seasonal and inter-annual variations in climate on carbon and water budgets at the sites with different age distributions, to increase our understanding of a transition of carbon cycling with ecosystem regeneration.

Net ecosystem CO_2 exchange (NEE), total ecosystem respiration (RE) and gross primary production (GPP) were estimated from 2001 to 2003 at the OJP and HJP94 sites. We conclude that the nighttime NEE at both sites had a positive correlation with soil volumetric water content (VWC), as well as with soil temperature, in warm growing seasons but was almost independent of VWC in cold dormant seasons. The positive correlation with VWC was more apparent at HJP94 than at OJP.

The high sensitivity of GPP and RE to VWC variations was more obvious at HJP94, probably related to the severe water stress on the photosynthetic and respiratory activities caused by poor water holding capacity of the sandy soil layer and the shallow root system of the young trees, many of which were less than ten years old. At HJP94, the relatively large RE, which sometimes exceeded GPP, was caused by high respiration rate and low LAI. The decomposition of remaining dead plant mass, either buried or on the ground surface, likely contributed to the large RE at the site. Since VWC displayed a strong seasonal variation in a shallow surface soil layer, it could be an important seasonal environmental factor governing photosynthetic and respiratory activities at sparse young forest stands like HJP94.

O13

EDDY COVARIANCE SENSIBLE AND LATENT HEAT FLUXES FOR THREE YEARS ABOVE A JAPANESE CYPRESS FOREST WITH COMPLEX TOPOGRAPHY

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Typical plantation forests in the mountains of Japan are evergreen coniferous forests. Evapotranspiration from these forests greatly influences hydrological and micrometeorological processes and also the environmental functions of the forests. Annual evapotranspiration is a component of the water cycle and can be estimated using the water balance method to elucidate the relationship with annual precipitation. However, an approach using annual hydrological data cannot rule out controlling factors or their influences on the characteristics of evapotranspiration. As a result, differences based on forest type cannot be studied in depth. In contrast, evaluation of evapotranspiration using eddy covariance heat fluxes coupled with micrometeorological data allows analysis of the factors that control evapotranspiration. Analysis of dry-canopy transpiration measured with the eddy covariance method will yield information on stomatal behavior and influence on heat, water vapor, and carbon dioxide fluxes. Understanding how dry canopy transpiration interacts with photosynthesis and is influenced by stomatal regulation is critical for understanding gas-exchange processes. Diurnal, seasonal, and inter-annual fluctuations in evapotranspiration and bulk parameters, which include surface conductance (Monteith, 1973) and decoupling factor (McNaughton and Jarvis, 1983), can and should be evaluated for various vegetation types using long term flux datasets.

There is a possibility that surface conductance is underestimated in the eddy covariance method because of an energy closure problem (the imbalance problem), i.e., sensible and latent heat fluxes are underestimated. Accurately measuring energy fluxes for the eddy covariance method may be difficult, especially for forest sites with complex topography. The imbalance problem has been noted in many sites. Whether eddy covariance data provide accurate information so that heat fluxes and evapotranspiration can be evaluated is a question that must be answered for individual sites.

In this study, we analyzed sensible and latent heat fluxes for 3 years (2001 to 2003) over a Japanese cypress forest with complex topography in central Japan. The observation site (Kiryu Experimental Watershed) was established in 1967 to study hydrological water circulation and to evaluate the roles of trees and soil in the forest. It represents one of the longest continuous research programs in Japan and has 33 years' reliable hydrological datasets from 1972. We also compared the evapotranspiration estimated with eddy covariance method with those estimated with long-term and short-term water budget methods for the validation.

A detailed assessment of the energy budget closure was performed to reveal the diagnosis of energy imbalance. The assessment of the energy budget closure coupling with the comparison between eddy covariance and water budget methods revealed that eddy covariance method underestimated the evapotranspiration even after careful data quality check. The underestimation during and after rain with closed path method was especially critical. Our suggestion for the practical solution is to apply the correction to the eddy covariance sensible and latent heat fluxes to close the energy budget. Comparison of eddy covariance method with long-term and short-term water budget methods also suggested the necessity of some corrections.

The observations described the magnitude and seasonal and inter-annual variations in sensible and latent heat fluxes, evapotranspiration and the parameters describing bulk canopy characteristics. This forest was characterized by relatively small values of surface conductance and decoupling factor compared to other forests. However, several other coniferous forests in the literatures showed smaller values. Surface conductance, and thus stomatal regulation, is important in controlling dry-canopy transpiration in this forest. Both amplitude and characteristics of seasonal fluctuation of evapotranspiration and surface conductance showed no significant inter-annual differences in spite of considerable fluctuation in precipitation and thus soil moisture condition.

O14

A novel mass-balance technique for measuring CO2 fluxes in nocturnal drainage flows beneath a forest canopy

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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:

$$F_0 = F_h + \frac{1}{A}\int_0^L \int_0^h \Delta(uc)dzdy + \frac{1}{A}\int_0^L \int_0^h \Delta(vc)dzdx\,, \qquad (1)$$

where F_0 is the flux at the lower boundary, F_h is the flux through the upper surface at height h, and $\Delta(uc)$ and $\Delta(vc)$ are the change in horizontal fluxes across the y-z and x-z planes, respectively. 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

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

and thus Equation (1) becomes

$$F_0 = F_h + \frac{u_h}{L}\left[\int_0^h S(z)c_{yz}(z)dz\Big|_d - \int_0^h S(z)c_{yz}(z)dz\Big|_u\right] + \frac{v_h}{L}\left[\int_0^h S(z)c_{xz}(z)dz\Big|_d - \int_0^h S(z)c_{xz}(z)dz\Big|_u\right] \qquad (3)$$

where the subscripts *yz* and *xz* represent the y-z and x-z planes, and *d* and *u* stand for the downstream and upstream faces of the control volume. Note that $S(z)$ can be considered a weighting factor for the concentration at each height, and provided the profile $S(z)$ is constant, it can be used as a scaling factor to sample the air at each height.

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.

O15

Introduction to CMA Flux Network

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Background: The secular increase occurring in carbon dioxide concentration may help stimulation of photosynthesis, crop growth and water use efficiency. However, its potential adverse effects include global warming, perturbations of regional precipitation and soil moisture patterns. China Meteorology Administration (hereinafter, referred to as CMA) needs to investigate the global carbon and water cycle with an emphasis on assessments of surface fluxes within China landscape for better understanding how surface fluxes respond to the change in climate and in ecology. Knowledge about the surface flux is also critical for CMA to develop societal policies on future energy use. In a word, CMA was aware that establishing of flux network would significantly improve our operational work, and therefore is our responsibility too. To quantify the seasonal variations of carbon dioxide and water vapor fluxes, the Fluxnet (AsiaFlux, AmeriFlux, EuroFlux and other) has been operating since 1990s. CMA would like to deeply involve into this network for sharing the benefit within the Fluxnet and for contributing our energy.

What is being done? Recognizing a need for long term measurements, we installed three flux towers in April of 2004. They were equipped with same instruments (CSAT3, and LiCor 7500) for the fast response measurements and have been operating well since beginning. The synchronous slow response measurements (i.e., gradient air temperature, humidity, and wind speed; soil temperature and liquid water content) have been also conducting. The surface types mainly are croplands. The time series of data are ready for analysis. Meanwhile, two dust-storm towers were installed in the suburb of Beijing in north China for monitoring dust-storm, where the fluctuating wind speed and fluctuating air temperature have been collecting since the February 2005. The surfaces are sparse grasslands. In addition, four flux towers are under construction for capturing heat and water fluxes over urban and desert surfaces respectively. In a work, the CMA flux network is growing well now and will be developed further.

What is CMA Flux Data Policy? We are designing a website for releasing data to colleagues within Fluxnet. This website will provide us a bridge of our cooperation.

What are Future Plans? We plan to convene a workshop on 'Strategies for Long Term Studies of CO_2 Heat and Water Vapor Fluxes over Terrestrial Ecosystem' at the end of 2005 in Beijing. Similar to that held during March, 1995 in LaThuile, Italy, the explicit goals of the workshop is to assess the state-of-art of making long term flux measurements and to obtain advice and consensus on the direction of future long-term flux research.

How Can Get More Information? The CMA Flux program is led by Prof. Bian Lingen at Chinese Academy of Meteorological Sciences, CMA. Information about CMA Flux may be obtained via the upcoming website or via emailing Prof. Gao Zhiqiu at zgao@cams.cma.gov.cn.

S11

SEASONAL CHANGE MONITORING OF FOREST ECOSYSTEM BY REMOTE SENSING

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Main characteristics of natural disturbances and human-induced stressors affecting on forest ecosystems are considered as: frequency (number of occurrences per unit time), extent (area over which the event occurs), intensity (degree of effect), and duration (length of stressor event). These four aspects are summarized in "spatial" and "temporal" resolutions in remote sensing parameters. Therefore, these two aspects are essential for appropriate monitoring designs. Although remote sensing data give us various information of forest ecosystem, appropriate "indicators" are also required for monitoring forest ecosystem.

Because natural and human-induced stressors affect forest area for a long time, "prediction" models based on previous monitoring data are important for evaluating the apparent phenomena. However, "appropriateness" of monitoring system using remote sensing is not yet clear and the conceptual structure on monitoring design is required worldwide.

Therefore, monitoring and modeling of seasonal change is an essential task for environmental studies in forested area and appropriate monitoring design should be adopted. Remote sensing technology is considered one of the useful and important tools for monitoring various forests in the world. Especially, remote sensing data with high frequent observation capability play important role for monitoring and modeling of seasonal changes.

This presentation shows some examples of monitoring designs and the products of “indicators”, which were created from seasonal change models applied to satellite remote sensing data, such as NOAA-AVHRR, SPOT-VGT, and MODIS.

S12

CONTRIBUTIONS OF ASIAFLUX TO INTEGRTED GLOBAL CARBON OBSERVATION

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The ten-year implementation plan of the Global Earth Observation System of Systems (GEOSS) endorsed by Earth Observation Summit proposes to develop a plan to ensure comprehensive and sustained earth observations. The carbon observation system is one of the most important components of GEOSS. The carbon group of Integrated Global Observation System (IGOS) has proposed a strategy to realize a coordinated system of Integrated Global Carbon Cycle Observations (IGCO). The two main objectives described in it are;

(1) To provide the long-term observations required to improve understanding of the present state and future behavior of the global carbon cycle, particularly the factors that control the global atmospheric CO_2 level.

(2) To monitor and assess the effectiveness of carbon sequestration and/or emission reduction activities on global atmospheric CO_2 levels, including attribution of sources and sinks by region and sector.

The requirements to implement the above observations are;

(a) Consolidating data requirements, designing network configurations, and developing advanced algorithms for assimilating carbon observations, which will be the core of a future, sustained operational system by 2015,

(b) Developing cost-effective, low maintenance, *in situ* sensors for atmospheric CO_2, ocean dissolved pCO_2, and terrestrial ecosystem fluxes,

(c) Developing and implementing technologies for remote sensing of CO_2 from space,

(d) Improving estimates of biomass based on national inventories and/or remote sensing observations,

(e) Developing, operational carbon cycle models, validated through rigorous tests and driven by systematic observations that can deliver routine diagnostics of the state of the carbon cycle, and

(f) Enhancing data harmonization and intercomparability, archiving, and distribution to support model development and implementation

AsiaFlux will play an important role to understand the present state of carbon cycle in terrestrial ecosystems (c,d) in Asia, and the long-term and systematic flux observation will provide us the better prediction of future carbon cycle in different climate from now.

There are several on going or under planning activities in Asia related to carbon. The *in situ* atmospheric CO_2 observation is limited to Japan, China and Korea, but the observation on the passenger aircrafts of Japan Airline is starting very soon, and the South-east Asia area is expected to be covered. A project of *in situ* observation on cargo-ships in South-east Asia is stating from 2006. These projects just fit to the proposal of (b) in the sense of cost-effective and low maintenance. The satellite observation project, Greenhouse gases Observing SATellite (GOSAT) is under progress targeting to be launched in 2008 (c). The Asia Integrated Model (AIM) group is improving the national inventory of anthropogenic emissionmainly, but it will be extended to cover terrestrial ecosystems (d).

These activities are desirable to be integrated and a complimentary observation system will be established in Asia.

S21

MEASURING FLUXES IN COMPLEX TERRAIN

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Difficulties with eddy-correlation measurements in complex terrain are surveyed with examples from field sites in central Oregon, USA. The strategy for using fluxes to estimate the Net Ecosystem Exchange is briefly reviewed. In complex terrain, estimation of fluxes and NEE is complicated by height-dependence of the wind and flux fields within the canopy due to drainage and upslope flows and advection by such flows. Location bias and systematic errors in quantification of horizontal advection is also discussed. Estimation of vertical advection by such flows is problematic due to apparent inability of sonic anemometers to measure mean vertical motion. Mean vertical motions estimated from measured horizontal divergence and mass continuity yield vertical motions that are more systematic and in better agreement with physical expectations compared to those estimated from sonic anemometers.

Traditional averaging lengths for computing fluxes are found to be inappropriate in very stable conditions, leading to large random flux errors. These problems are most important in low-lying areas with weak nocturnal airflow. Biases in existing approaches for estimating carbon dioxide fluxes are summarized.

S22

LONG-TERM CO_2 FLUX MEASUREMENT AT TAKAYAMA SITE

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Takayama site is located at 36 ° 08'N, 137 25' E. The highest Elevation is1420m, the vegetation type is cool temperate deciduous broadleaf forest, the dominant species are *Birch and oak forest,* the canopy height is 15~20m, and Age is 30~40 years. A 25m tower was built up in 1993, and CO_2 flux measurement continues since then; before 1998 by aerodynamic method, and after 1998 by eddy covariance method. The location of the tower is at the top of a small peak. Figure 1 shows the topography around the tower. The west side of the tower is very steep slope, but vegetation covers the all the direction. Figure 2 shows the relation between the ratio of vertical wind velocity (w) to horizontal wind velocity (u) and wind direction. These are 30 min. average during 1 to 4, Aug., 1995. The figure indicates that the prevailing winds are NE and WSW, and vertical wind velocity is much affected by local topography. Diurnal variation of the wind is westerly in the daytime (valley to mountain) and opposite direction at night, and this local wind variation affected on the daily variation of CO_2 concentration (Kondo et al., 2001).

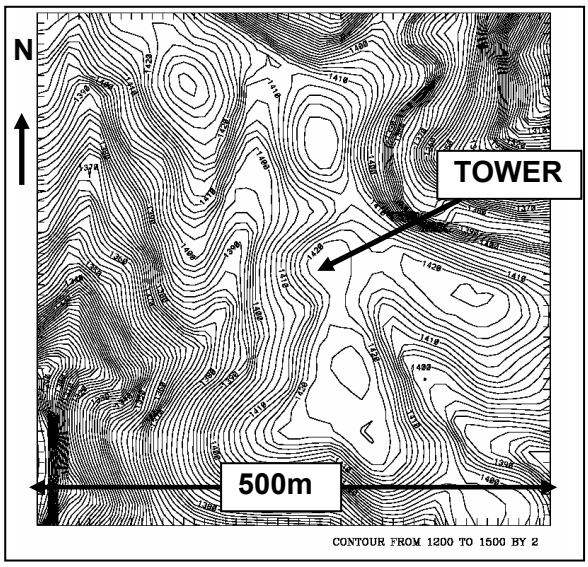

Fig.1 Topopgraphy around Takayama site. The counter lines are drawn at 2m interval.

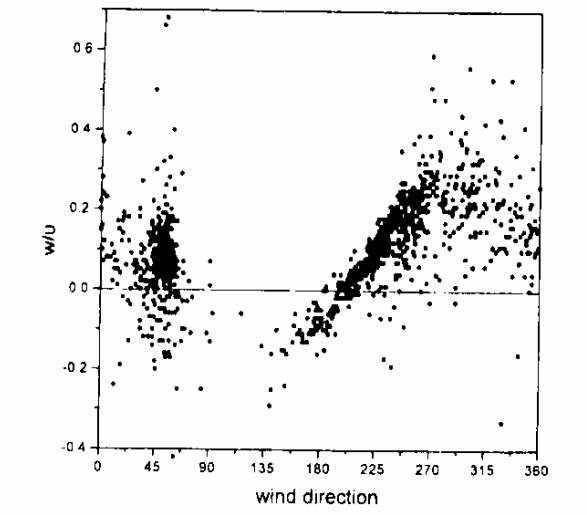

Fig.2 The relation between w/u and wind direction at the tower top.

At present, what we recognized as the problems due to complex terrain are as follows;

1) The appearance of $u_*^2 > 0$ is higher than that observed at the site on the relatively flat terrain, such as Tomakomai.

2) Separation of the flow between at the tower top and near the slope surface often occurs under the stable condition at night, which causes to underestimation of CO_2 eflux due to respiration.

The attempt to overcome these problems will be introduced.

Reference

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S23

ESTIMATION OF ECOSYSTEM RESPIRATION OF A SUBTROPICAL *PINUS* PLANTATION OVER HILLY REGION IN SOUTHEASTERN CHINA

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Long-term measurements of the exchange of CO_2 between natural and planted vegetation and the atmosphere have the potential to markedly improve understanding the role of terrestrial ecosystems play in the global carbon cycle. Eddy covariance (EC) is a micrometeorological technique that allows a non-invasive measurement of the exchange of CO_2 between the atmosphere and a several hectare area of forest, shrubland, or grassland. Expanding the scope of the FLUXNET database, ChinaFLUX offers new opportunities to quantify and compare the magnitudes and dynamics of annual ecosystem carbon and water balance and to explore the biotic and abiotic effects on ecosystem processes of carbon dioxide and water vapour exchange that are unique to ecosystems in China.

However, reliable flux measurements at nighttime or at sites subject to advective flows remains a serious obstacle to routine 24 hour operation. At night, flux corrections based on u_* thresholds are widely applied to replace aerodynamic estimates when turbulence is weak and the sum of eddy fluxes and storage terms fails to give convincing measures of CO_2 respiration. Similarly, rapid flushing of the canopy CO_2 at dawn or during intermittent turbulent events in stable conditions is usually spatially localized and may lead to systematic bias in estimates of regional exchange from a single tower. Many sites, chosen for reasons other than micrometeorological convenience such as Qianyanzhou flux site in ChinaFLUX, a subtropical *Pinus* plantation on the red earth hilly region of southeastern China, suffer from systematic advection in some or all wind directions. Operational approaches to correct for advection are not yet available.

Accuracy estimation of ecosystem respiration over tall vegetation in difficult condition was one of the major issues within the FLUXNET network, so did ChinaFLUX. To be able to compare the results of flux data of different flux measurements, the quality of the flux data must be assessed and controlled. Motivated in larger part by the need to address this question in ChinaFLUX, we analyzed the turbulence flux measurements using the EC technique at two and three canopy heights of Qianyanzhou subtropical *Pinus* plantation on the red earth hilly region of southeastern China in 2003 and 2004. The objectives of this paper focus on 1) how to assess the nocturnal flux underestimation, and 2) how to estimate the daytime ecosystem respiration to determine gross primary production, and 3) how to determine the seasonal pattern of ecosystem respiration.

The turbulent flux measurements made at two heights were within the surface layer. However, stationary test and integral turbulence test indicated that nocturnal CO_2 flux measurement was still under debate. A way to correct for flux underestimation during stable nighttimes is to replace the measured fluxes below the threshold of 0.2~0.3 m s^{-1} by the simulated efflux by a temperature and moisture function derived during well-mixed conditions at Qianyanzhou flux site.

The use of the annual respiration values derived from nighttime EC data may not be suitable for studies where heterogeneity and fetch limitation exist. Given the potential problems associated with nighttime EC measurement, such as inadequate turbulent mixing, advection, extended flux footprints, and so on, the potential difference in physiological behavior between daytime and nighttime, and the consistency of annual ecosystem respiration, which was derived from daytime light-response analyses and nighttime EC estimates, suggest that our study site was not significantly affected by heterogeneity or fetch problems.

Although ecosystem respiration showed a decline trend during the severe drought during the summer of 2003, net carbon uptake of this planted forest still declined obviously and even become a small carbon source. In essential, net ecosystem CO_2 exchange and ecosystem respiration at daily and monthly scales were determined by the gross ecosystem CO_2 exchange. Small differences in these large biospheric fluxes account for day-to-day difference in carbon storage by terrestrial ecosystem.

S24

DIVERSIFIED EVALUATION OF NEE ESTIMATED BY EDDY-COVARIANCE, CHAMBER AND BIOMETRIC METHODS ABOVE TEMPERATE DECIDUOUS FOREST IN CENTRAL JAPAN

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INTRODUCTION

In a temperate deciduous forest in Japan situated complex terrain, net ecosystem CO_2 exchange (NEE) was estimated using micro-meteorological method, measures of fluxes using chamber and biometric methods. U* threshold for interpolation of nighttime flux and seasonal change of function to estimate nighttime flux was evaluated using respective results.

SITE AND METHODS

Measurements were conducted at the Yamashiro Experimental Forest (YEF) in Kyoto, Japan. The plot area is 1.7ha. Forest type is a secondary deciduous broad-leaved forest and *Quercus serrata* and *Irex pedunculosa* are dominated. Stand density is 3209 ha^{-1}, mean crown height is about 12m and living biomass (DBH≥3cm) is 44.5tC ha^{-1} (Goto *et al*., 2003). Eddy covariance CO_2 flux measurements were conducted using a closed-path method at 26.5m height and vertical profiles of CO_2 concentration from air samples taken at 8 different heights using gas analyzer (LI-6262). In this study, we used eddy covariance flux data obtained from 1 January 1999 to 31 December 2003. Above and below ground net primary production were estimated based on allometric relationships and DBH census (Goto, 2003, Dannoura, 2002). Allometric relationships between size parameters and dry weight of stems, branches, leaves and roots were established using 46 and 16 trees for above and below ground biomass respectively. And DBH census was conducted for all trees (1cm=<DBH) in 1994 and 1999. CO_2 flux from foliage was estimated using 4 automated chambers and LAI measurements (Miyama, 2005a). CO_2 flux from soil (Fs) was estimated by 2 automated and 16 manual chambers (Tamai, 2005). Estimation function for Fs was established using the data of soil temperature (Ts) and soil water content (θ). CO_2 flux from CWD was estimated by 2 automated and 192 manual chambers measurements and CWD census in 2003 (Jomura, 2005). CO_2 flux from stem was estimated by 2 chambers measurements and the data of stem surface area estimated by allometric relation between stem surface area and DBH (Miyama, 2005b). By integrating each CO_2 flux, CO_2 flux from forest was estimated by chamber method.

RESULTS AND DISCUSSIONS

Averaged net uptake of CO_2 measured by eddy covariance method from 1999 to 2003 was 3.4 tC yr^{-1} ha^{-1} without compensation of nighttime underreports. Estimated NEP(=NEE) using biometric measurements from 1994 to 1999 was 1.56 tC yr^{-1} ha^{-1}. U* threshold based on biometric NEP were 0.28 m sec^{-1} and regression function which relate nighttime CO_2 flux and soil temperature at 5cm depth (Ts) was

$$Fco_2=0.02443EXP(0.0912\ Ts)$$

Annual averaged regression function obtained by chamber measurements showed good agreement with the function by eddy covariance method using the u* threshold as 0.35 m s^{-1}. Assuming the u* threshold as 0.32 which was mean value of two evaluations, annual NEP obtained by eddy covariance method varied from 1.29 to 1.68 tC yr^{-1} ha^{-1} from 1999 to 2003.

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S25

EVALUATION OF NOCTURNAL CO_2 EXCHANGE BASED ON DETAILED MEASUREMENTS OF CO_2 BALANCE IN A JAPANESE CYPRESS FOREST

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Introduction

Underestimation of nocturnal CO_2 respiration with the eddy covariance method under calm conditions remains an unsolved problem at many forest flux stations. In this study, to evaluate nocturnal CO_2 exchange in a Japanese cypress forest with complex topography, we observed CO_2 flux above the canopy (F_c), changes in CO_2 storage in the canopy (S_t) and soil, trunk and leaf respirations (F_s, F_t and F_l). In addition to these measurements, we observed the wind speed on the forest floor and checked whether there was a drainage flow, which is considered as one of the causes of underestimation.

Site and Methods

Our observation site is located at the Kiryu Experimental Watershed (34° 58' N, 136° 00' E) in Shiga Prefecture, Japan. The site is mainly covered by *Chamaecyparis obtusa* Sieb. et Zucc. (Japanese cypress, an evergreen conifer). This area has a mild northward inclination of approximately 9.2°. The canopy height is approximately 18 m and the total leaf area index (LAI) ranges from 4.5 to 5.5. The annual mean air temperature from 2003-2004 was 13.3℃ and annual mean precipitation from 2003-2004 was 1884 mm.

We measured wind speed and CO_2 concentration at 10 Hz with a three-dimensional sonic anemo-thermometer and an open-path IRGA at 28.5m and calculated F_c by the eddy covariance method. The reference frame of the co-variances was rotated for every 30 min flux measurement to align the flux perpendicular to the mean streamline. WPL correction for the effect of air density fluctuations was applied. The data that does not meet the stationarity was rejected. We also calculated S_t from the vertical CO_2 distribution measuring 5 (or 6) heights density. NEE was estimated every 30 min from F_c and S_t.

Each component of ecosystem respirations (F_s, F_t and F_l) was observed by the chamber method. Five automated closed dynamic chambers for soil (3), trunk (1) and foliage (1) were installed for the continuous observation. Soil respiration rate observed with the automated chambers at the three positions was compared with that observed with a closed chamber air circulation method using home-made chambers and an IRGA at 100 positions located over the watershed, to validate the spatial and temporal representativeness of the data obtained with the three automated chambers. Trunk respiration rate observed with an automated trunk chamber was assumed to be a representative value of this site and scaled to the values per unit ground area (F_t) using census data around the flux tower. Several methods for the scale up were compared to evaluate the uncertainty caused by the difference of the scale up method. The foliage respiration per unit ground area (F_l) was scaled from an automated foliage chamber data. The coefficient for the scaling was derived from the budget with F_c, S_t, F_s, and F_t, with the assumption that F_c was measured precisely at high friction velocity (u_*) in the daytime. The validity of this method was checked comparing with LAI and leaf respiration rate per unit leaf area measured at several heights in the canopy. The underestimation of nocturnal CO_2 respiration by the eddy covariance method was evaluated comparing F_c+S_t to $F_s+F_t+F_l$. In addition to these observations, three-dimensional wind speed was measured at 2 m-height on the forest floor and compared with that of above the canopy to investigate the existence of drainage flow.

Results and Discussion

Comparison of nighttime F_c+S_t to $F_s+F_t+F_l$ verified that F_c+S_t underestimated ecosystem respiration ($F_s+F_t+F_l$) at low u_*. The frequency of south wind (downward along the slope) was dominant below the canopy regardless of the wind direction above the canopy at low u_*. This suggested the drainage flow at this site under calm condition. Nighttime ecosystem respiration estimated with chamber method nearly equaled to F_c+S_t at high u_*. This result in our site provides a positive prospect for the correction of the nocturnal CO_2 flux replacing the data with low u_* by the temperature response functions from the data with high u_*, although the spatial and temporal heterogeneity in ecosystem respirations should be evaluated more precisely at each site.

S26

Interpretation of fluxes in non-ideal conditions

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Abstract

This paper reports on the impact of surface patchiness on CO_2 fluxes. Using a combination of surface-atmosphere exchange models, tracer and CO_2 fluxes and turbulence measurements, this paper demonstrates how adjoining lands of contrasting surface properties upwind, though located hundreds of meters away or more, impact tower CO_2 fluxes. The influence of the size of upwind surface patches on fluxes is also discussed.

This paper draws examples obtained from several flux research sites. It discusses important flux enhancements imparted by surface inhomogeneities upwind in daytime conditions and identifies several physical mechanisms significantly altering CO_2 fluxes in nocturnal conditions. Results from this work shed a new light on the interpretation of surface-atmosphere exchange of CO_2 in non-ideal terrain.

S32

Climate Change Activities in Forestry Sector : Current and Future R&D in Malaysia

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Abstract

Malaysia signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1993 and ratified it in 1994 and has since doubled its efforts to fulfill its obligations. A National Climate Change Committee was established to help meet its obligations under the Convention. In addition, an Initial National Communication was submitted to UNFCCC in 2000. Malaysia is in the midst of preparing its second National Communication.

Efforts into improving the scientific knowledge base on the potential of Malaysian rainforest as CO_2 sink or source is being intensified. Research activities identifying the key carbon pools of each key forest types are on-going. Along these lines, research programmes to address how land-use affects the changes in stocks and estimate the effects of land-use and land-use changes on the emissions and removals of CO_2 is being done. In addition, the impacts of projected climate change on key forest species are also being investigated. This paper will highlight the current and future research activities related to climate change and carbon inventories in forestry sector in Malaysia.

S33

Agricultural and Forest Meteorology Research Work in Thailand

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ABSTRACT

Thailand has 6 Tower Flux Sites, which constructed by the AsiaFlux for conducting the research work in agricultural and forest meteorology. Maeklong and Sakaerat flux sites belongs to Asia Flux network were operated by Dr. Minoru Gamo et al., (2001-present), which have the objective of the research as to evaluate CO_2, water vapor and heat exchange in tropical seasonal deciduous forest. To Daeng To Daeng, and Bacho Bacho flux sites in Narathiwat province (Southern part) was investigated by Dr. Tomoyasu Ishida et al., (1994-present), which have an objective to grasp and renovate the actual conditions of destroyed environment, and to develop local appropriate technology of sustainable biological production of tropical forest. One flux site in Phangnga province (Southern part) was operated by Dr. Nobutaka Monji et al., (1996-1998), has the objective to study for CO_2 exchange and heat flow in mangrove forest. The Tak flux measurement (TFM) site, one of the sites of Korean Flux Network (KoFlux) which is an infrastructure of AsiaFlux, is constructed at a Northwest of Thailand and operated by Dr. Wonsik Kim et al., which have an objective to construct a KoFlux prototype of data information system (KoFlux-DIS), which is an infrastructure for a seal time monitoring and simulation system incorporating comprehensive data management of tower flux measurements.

There are already several Flux sites in Thailand but it need to find an ecosystem that has been overlooked or left out by the current Thai network especially in the upper North. In the northern part of Thailand the rate of forest loss by deforestation have been relatively modest in the last two decades, with a reduction in forest cover from 52 percent in 1982 to 44 percent in 1995 and even of an increasing more in recent years. There are several activities that involve biomass burning which is the principle source of air pollution; for example slash and burn agriculture especially in the upland and highland areas, and the establishment of permanent farms and cattle ranches, the clearing for which also involves the burning of large amounts of forest materials. Cruzen (2003) estimated $1.8\text{-}4.7\times10^{15}$ gC of biomass are burned each year in the tropics, compared to the amounts of 5.5×10^{15} gC/year of fossil burning. No research work has been done on the biomass burning as a pollution source and limiting in the studies of soil-vegetation-atmosphere interaction in the upland and highland agricultural system.

One of the serious causes for the social and economic weakness of Thailand is the severe shortage of highly qualified human resources especially in the field of science and technology. Agricultural meteorology and micrometeorology is the one of the most severe shortage area. There have some scientists from the Royal Forest Department working with the Asia Flux network, and have some course work in agricultural

meteorology offered for the undergraduate students in some universities. No Ph. D. graduated in agricultural meteorology has been produced by the Thai University. Previous attempts to solve this problem, the Thailand Research Fund, a state research funding agency was initiated a Royal Golden Jubilee (RGJ) Ph. D. program by giving scholarships for the talented student to gain about 6-12 months international research experience.

With a shortage of a well-trained personnel in micrometeorology, it would be good for Thailand in terms of to developing the course in agricultural meteorology and micrometeorology. This course would be beneficial immediately to all scientists throughout Thailand, Laos. Cambodia, Malaysia, Vietnam and South of China. The course would be particularly helpful if it can set up a flux site near Chiang Mai University, and should prepare graduate students, post docs, and professors as well as government scientific personnel in the basic principles of micrometeorology / agricultural meteorology. This may be of interest to scientists who work in agriculture, in forestry (ecophysiology), agricultural and civil engineering, environmental sciences, atmospheric sciences, botany, and biology. To tackle these severe shortages we need the collaboration and support from AsiaFlux. With so much photochemical activity in the tropics, it is very unfortunate that we know very little about the atmospheric chemistry in these regions. Thus, an important goal for the future research is to gain a better understanding about chemical processes in these areas. The tropics and subtropics, especially Asia, contain an increasing proportion of the world's population, which is under rapid development. The large change in atmospheric chemistry and climate forcing during the coming decades will therefore largely come from these region. CO_2 has a concentration of approximately 370 per million air molecule, together with water vapor and sunlight, it builds the organic molecules of living matter. As a so-called greenhouse gas, CO_2 is also significant for the Earth's climate. However, despite these important aspects, it plays no role in atmospheric chemistry. O_3 and water vapor are the most important drivers of the photochemistry of the atmosphere. Without O_3, the chemistry and chemical composition of the atmosphere would be totally different.

There was an interaction found in between CO_2, O_3 and UV-B as the stress factors. An increase of UV-B in the troposphere will promote ozone formation. Ozone and UV-B are known to reduce bio-productivity and therefore less carbon is sequestered in biomass. This response of plants will contribute to the increase of CO_2 in the atmosphere. Higher temperatures (greenhouse effect) and CO_2 seem to reduce the sensitivity of some plants to ozone and UV-B. This synergism is not understood at all, but due to the high cost of "crucial" experiments to gain reliable results, they are not performed frequently.

This paper was prepared for the AsiaFlux workshop 2005, which will be held in Fujiyoshida, Japan, August 24-26, 2005.

S34

MICROMETEOROLOGICAL RESEARCH AND FLUX STUDIES IN BANGLADESH – CURRENT STATUS AND FUTURE PROSPECT

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Geologically, Bangladesh is a part of the Bengal Basin, one of the largest geosynclinals in the world. Physiographically, the country can be divided into hills, uplifted land blocks, and the majority alluvial plains with very mean elevation above sea level. Climatologically, it is characterized by high temperature, excessive humidity, and fairly marked seasonal variations of precipitation. Bangladesh experiences abundant rainfall during the monsoon (July-October) followed by a cool winter period (November-February), and then a hot dry summer (March-June).

Bangladesh is highly suitable for crop production. The total land area of Bangladesh is approximately 35 million acres (14 million hectares) of which around 20 million (8 million hectares) or 55.5% of the total area is under cultivation. This is one of the highest percentages in Asia. Seventy percent of the population depends on agriculture. Agriculture is the life nerve of Bangladesh. It contributes 34% to the Gross Domestic Product (GDP). Most of the cultivable land covers with rice based cropping pattern as Rice-Fallow-Rice or Rice-Rice-Rice. And also different types of cereal crops, pulse crops, vegetables, fiber crops, oil crops are cultivated in agricultural sector. Biomass (wood, crop residues, dung) fuel constitutes 73% of total energy consumption and per capita supply is declining gradually which is the principal source of air pollution.

Ecologically, Bangladesh plays a major role with the contribution of terrestrial and aquatic ecosystem. Terrestrial ecosystem includes Dipterocarp forest, Savannas, Bamboo forests, swamp forest, natural inland Sal forest, littoral Mangrove Forest and aquatic ecosystem includes freshwater and coastal wetland. The total land under forest in Bangladesh is about 2.56 million hectare. In Cox's Bazar, natural forest cover dropped from 31,300 ha in 1985 to about 24,300 ha in 1992. In Sundarbans, 78% of the forest had canopy closure of 75% or more in 1961, which was reduced to 65% in 1984. As of 1989 only about 17% of the total legitimate Sal forest area remained across central and northwest of Bangladesh (FMP, 1995). The total area of the wetlands in the country has been variously estimated at seven to eight million hectares, or about 50% of the total land surface. No research work on micrometeorology/ flux measurement has been conducted on any ecosystem in our country in the past.

In Bangladesh, there are 36 meteorological stations among 64 districts (under Govt. supervision). They record traditional meteorological parameters with their age-old instruments and process their data manually. Space Research and Remote Sensing Organization (SPARRSO), SAARC Meteorological Research Centre (SMRC), EGIS work with collected meteorological data through Remote Sensing, Satellite Image and Geographical Information System.

International Union for Conservation of Nature and Natural Resource (IUCN) and United Nations Development Programme (UNDP) have several countries programmed to conserve biodiversity in different ecosystems. Food and Agricultural Organization (FAO), CARE and Bangladesh Agricultural Research Council (BARC) work with vulnerability, climate change and adaptation. Department of Environment (DoE) under the Ministry of Environment and Forest (MOEF) and hundreds of NGOs involved in different categories of environmental programme like air pollution, water pollution, soil degradation, waste management *etc*. But their works are limited in survey based data and awareness building rather than technological development.

There was no course on micrometeorology for students in any University of Bangladesh till 2002, though micrometeorological research started in 1998 after coming back of Dr. Baten from Chiba University, Japan, with a very limited scope at Bangladesh Agricultural University (BAU) with few portable sensors. By adding a few more sensors with a datalogger provided by National Institute for Agro-Environmental Sciences (NIAES), Japan in September 2002, Dr. Baten is now offering courses to MS students of the Department of Environmental Science of BAU on micrometeorology and has started research on it. Some MS students are working on crop micrometeorology for their dissertations on energy balance, heat storage and radiation use

efficiency over different ecosystems. We wish to start measurement of micrometeorology in details with water vapor and CO_2 fluxes soon over rice ecosystem with collaboration of NIAES. Since Bangladesh is a rice-based country, flux measurement should be continued for 5-7 years. In addition our evergreen “sal forest” should be included for flux observation.

Identified obstacles for our research works are social and economic weakness, severe shortage of highly trained human resource, lack of scientific research centre and scientist and lack of sophisticated instruments. We have already several potential ecosystems for flux study, but we don’t have any facility to conduct such research. We would like to start collaborative research with Japan and thus we want cordial co-operation from AsiaFlux and FLUXNET for financial support, sophisticated instruments and trained manpower. This kind of collaboration will help to provide data to AsiaFlux from a densely populated rice based country for the development of future strategy to combat global warming.

S35

Status of forest carbon budget studies in India

At present, India being a party to the UNFCCC has initiated its first National Communication and emission inventory in various sectors, this was conveyed successfully to the UNFCCC in June 2004. As part of the NATCOM process, the emissions inventory from the forestry sector was assessed. The data source for this was mainly secondary in nature. The institutions that took part in this process were, Forest Survey of India, Forest Research Institute and Indian Institute of Science. The emissions from the forestry sector make up only one percent of the total national emissions.

The forest carbon budgeting efforts have been made to a very limited extent by Indian Institute of Remote Sensing. Besides, the mitigation potentials have been worked out by Indian Institute of Science through forestry mitigation projects using the current productivity rates and land availability. There is a dire need for generating primary information for CO_2 and other GHGs in forest ecosystems. No systematic or collaborative programme has been initiated so far. A preliminary attempt has been made by IIRS to establish a flux net tower in Nainital district of Uttaranchal, the modalities for which are in the process of finalization.

The Indian Council of Forestry Research and Education as a premier national research organization and custodian of forestry research for the last hundred years and would be interested in a collaborative effort to promote carbon budget studies in India. The organization has eight regional institutes at strategic locations all over the country, adequate strength of scientist and researchers to undertake this work and also coordinate the establishment of a flux network with State Forest Departments. Further, the scientific staff in ICFRE is adept and with the research on nutrient cycles, ecological sciences and forests and conversant with the climate change issues in forests. Here, I would like to highlight that the major clients for forestry research carried out by ICFRE are the State Forest Departments. The SFDs are also the custodians of forest resources and hence ICFRE could liaise very well to enable such a networking and locate ideal sites in representative forest types. The area in which ICFRE would like strengthening and support through the medium of AsiaFlux would be in expertise in handling the flux net tower operations and modeling for carbon budgets.

O21

A AUTOMATIC CHAMBER SYSTEM FOR MEASURING CONTINUOUS SOIL RESPIRATION BASED ON AN OPEN-FLOW DYNAMIC METHOD

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We developed an automatic opening and closing chamber system (AOCC) based on an open-flow dynamic method (open-flow AOCC). The AOCC can be used during all four seasons, even at the surface of relatively deep snow. We compared the open-flow AOCC with two closed dynamic methods (the AOCC configured as a closed dynamic system (closed dynamic-AOCC) and the LI-6400 system) under field conditions. The closed dynamic-AOCC and LI-6400 measurements were about 15.5% and 5.2% lower, respectively, than the values obtained with the open-flow AOCC. There was significant difference in soil respiration rate between the open-flow AOCC and the closed dynamic AOCC system. In contrast, no significant difference in soil respiration rate was detected between the open-flow AOCC and the LI-6400 system. In the field, the open-flow AOCC permitted long-term measurements under a range of temperature conditions and did a good job of reflecting the marked daily and seasonal variations in soil respiration as a function of soil temperature.

O22

Soil respiration in tropical seasonal rain forest and rubber plantation in Xishuangbanna, Yunnan, SW China*

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Abstract: Xishuangbanna is the most northerly situated tropical rain forest in the world and, as a result, has remarkable seasonal climate variations, which is different from tropical rain forests in other regions. In Xishuangbanna, the canopy of rubber plantations, *Hevea brasiliensis*, often form a single layer structure that is different from the multi-layer canopy of tropical seasonal rain forests.

Measurements of soil respiration rates were carried out for one year in a tropical seasonal rain forest in a Nature Reserve (21°57'N, 101°12'E) and a rubber plantation (21°56'N, 101°15'E). The two sites are about 5 km away near the Xishuangbanna Tropical Botanical Garden in Xishuangbanna, Yunnan.

The results showed that there was remarkable seasonal changes in the soil respiration rates in both the tropical seasonal rain forest and rubber plantation with changes in soil temperature at 5 cm depth, air temperature and soil water content. Soil respiration rates of the tropical seasonal rain forest and rubber plantation were greatest in October (9.24 $kgCO_2 \cdot m^{-2} \cdot d^{-1}$ and 11.06 $kgCO_2 \cdot m^{-2} \cdot d^{-1}$, respectively), and lowest in February (4.71 $kgCO_2 \cdot m^{-2} \cdot d^{-1}$ and 5.13 $kgCO_2 \cdot m^{-2} \cdot d^{-1}$, respectively). Soil respiration rates in May, June, July, August, September and October were higher than those in November, December, January, February, March and April. Soil respiration rates in the rubber plantation were significantly higher than that of the tropical seasonal rain forest (P ‹0.01). There was a significant correlation between soil respiration rates and soil temperature at 5 cm depth, air temperature, and the correlation between soil respiration rate and soil temperature (r^2= 0.87 and r^2= 0.82, respectively) was higher than that between soil respiration rate and air temperature (r^2= 0.80 and r^2= 0.72, respectively) (P ‹ 0.01) for the forest and plantation. There was a significant (P ‹ 0.01) correlation between soil respiration rates and soil water content in the forest and plantation (r^2= 0.73 and r^2= 0.63, respectively). The annual CO_2 efflux from the tropical seasonal rain forest and rubber plantation was 2.64 kg $CO_2 \cdot m^{-2} \cdot a^{-1}$ and 2.80 kg $CO_2 \cdot m^{-2} \cdot a^{-1}$, respectively. The Q_{10} values of the tropical seasonal rain forest and rubber plantation were 2.16 and 2.18, respectively. The Q_{10} value of the tropical seasonal rain forest measured by the alkaline absorption method in our study was slightly higher than the values measured using the static opaque chamber and gas chromatography techniques. The Q_{10} values of the seasonal tropical rain forest and rubber plantation in Xishuangbanna are higher than those reported in other tropical regions.

Key words: Tropical seasonal rain forest; Rubber plantation; Soil respiration; Q_{10}; Xishuangbanna

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O23

ISOPRENE EMISSION OF *QUERCUS SPP.* AND ITS CONTRIBUTION TO THE LEAF CARBON BUDGET

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Isoprene is a major volatile organic compound emitted from higher plant. Annual isoprene emission is estimated to be 220 TgC which is higher than the annual emission of non-methane hydrocarbons resulting from fossil fuel (IPCC 2001). One of isoprene emitters is *Quercus spp.*, but there is no available database for the tree species grown in Japan showing which *Quercus* species emits isoprene and which does not.

Isoprene quickly reacts with some kinds of reactive species such as OH, O3 and NO3 in the atmosphere. The life time of isoprene in the atmosphere is less than several min. It is finally converted to CO2 and this carbon emission is sometimes not negligible in considering carbon budget of leaf, whole plant and forest. We reported in a previous paper that carbon emission as isoprene from *Edgeworthia chrysantha* corresponds to 7% of carbon fixed by photosynthesis. In the present study, we collected volatiles from 12 *Quercus spp.*to identify the compounds emitted. Here we report the effects of leaf temperature and light intensity on isoprene emission of some *Quercus spp.*

Plants used here were *Q. serrata*, *Q. mongolica* var. *grosseserrata, Q. aliena, Q. dentate, Q. acutissima, Q. variabilis, Q. acuta, Q. glauca, Q. phillyraeoides, Q. salicina, Q myrsinaefolia and Q. sessilifolia.* A portable photosynthetic meter was used to measure photosynthetic rate and stomatal conductance. The leaf temperature and PPF in the cuvette were controlled. The flow rate entering the cuvette was set to be 500 umol/s. The volatiles in the cuvette was collected into adsorbent tube containing Tenax TA and Carbotrap. The volatiles were thermally desorbed and then analyzed with a gas chromatograph mass spectrometer. The isoprene concentration was often measured with a proton transfer reaction mass spectrometer (PTR-MS), allowing a real time monitoring of plant response to environment.

Among twelve species only deciduous trees *Q. serrata*, *Q. mongolica* var. *grosseserrata, Q. aliena,* and *Q. dentate* were identified as isoprene emitters. Isoprene emission from these plant species increased with an increase in leaf temperature up to 40 °C. Isoprene emission rate of these plant species at a leaf temperature of 40 °C ranged from 0.1 to 0.3 μmol(C) $m^{-2}s^{-1}$, which is corresponding to 5 ~ 20 % of carbon fixed photosynthetically. Their isoprene emission also raised with an increase in PPF and reached a plateau around 500 ~ 1000μmol $m^{-2}s^{-1}$, showing the change was similar to that of photosynthetic rate.

O24

Using ^{13}C to partition NEE into photosynthesis and respiration of broad-leaved Korean pine forest

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Terrestrial ecosystems played an important role in the global carbon balance and mitigating of global climate warming with the increase of CO_2 concentration. Net ecosystem exchange of CO_2 (NEE), water and energy are widely measured using the eddy covariance (EC) technique. Under-estimate of ecosystem respiration is one of great uncertainty during EC observation in the evaluation of forest ecosystem carbon sequestration function. Another challenge is attributed the abiotic and biotic factors to influences on the mechanism of ecosystem carbon metabolism which results in the annual NEE fluctuation. In order to overcome the weakness of eddy covariance technique and improve our understanding of the ecosystem ecophysiological behavior, stable carbon isotope technique is used to partition the NEE into photosynthesis and respiration components of broad-leaved Korean pine forest, which is the typical forest type in the northeastern of China.

Along with open path eddy covariance and meteorology measurements, on the 3-4 and 6-7 August of 2004, ambient air at 3 heights (0.5m, 24m and 32m) within the forest were sampled every two hours for determination of ^{13}C ratio of CO_2 using flask with custom-made sampling system. The measured CO_2 concentration and ^{13}C ratio are applied to determine the ^{13}C flux (isoflux of ^{13}C) and isotopic characteristics of ecosystem photosynthesis and respiration using Keeling plot technique etc. during the week pre and post sampling. Combined with EC and isotopic measurements, the NEE are successfully partitioned into photosynthesis and respiration components. The respiration flux derived from isotopic technique consists of about 40% of the total gross primary production (GPP) and 50% percent of NEE. In comparison with respiration flux derived from the NEE vs PPFD using nonlinear regression and extrapolation from the exponential dependence of nighttime NEE on air temperature with year round data, the isotopic derived is much higher with apparent diurnal trend. The PPFD technique derived respiration is the lowest and the air temperature derived one is the median with less diurnal change.

It is concluded that the stable carbon isotope technique combined with eddy covariance can be successfully used to partition NEE into photosynthesis and respiration components, and obtain more accurate estimate of ecosystem respiration to study ecophysiological dynamic response to environmental change.

Keywords Net ecosystem exchange, eddy covariance, Keeling plot, carbon flux

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O25

Carbon Isotope Composition of *Quercus serrata* (Japanese Oak) and *Caprinus laxiflora* (White Birch) Leaves grown in Gwangneung Forest

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Gwangneung site in Korea has been a center of intensive ecological, meteorological and hydrological researches during last ~10 years to understand forest-atmosphere exchanges of energy, carbon and water in a typical landscape of the country. We report carbon isotope data of *Quercus serrata* (Japanese Oak) and *Caprinus laxiflora* (White Birch) leaves collected in 2003 and 2004 from Gwangneung forest for an effort to characterize forest response to changing environmental conditions. Carbon isotope ratios of leaves exhibit remarkable temporal and inter-/intra-specimen variability. For both years, *Q. serrata* leaves are more enriched in ^{13}C than *C. laxiflora* leaves. For *Q. serrata*, leaves grown at higher level of canopy are more enriched in ^{13}C, which mainly correlates with vertical gradients in temperature and vapor pressure within canopy. Leaves of both species grown in 2004 are consistently depleted in ^{13}C compared to those grown in 2003. Carbon isotope fractionation during photosynthesis is mainly determined by the ratios between intercellular and ambient CO_2 concentration that is related to the stomatal conductance and photosynthesis rate. Precipitation and soil water content were higher in 2003 than in 2004, while temperature and radiation were lower in 2003. Presumably greater VPD favors low canopy conductance and high WUE in 2004 but higher radiation may result in a condition suitable for low WUE due to high stomatal conductance of the same year. In terms of carbon isotope data, greater Δ values in 2004 indicate a lower WUE of the year. A more complicated interpretation is derived if normalized nitrogen concentration in leaves is considered. The lower concentration of leaf nitrogen in 2004 likely indicates that Gwangneung forest (or at least two species studied) in 2004 had low 'Maximum Photosynthesis Ability' than in 2003. Without supplementary data, it is difficult to interpret how and why Gwangneung forest in 2003 and 2004 had different WUE and photosynthesis rate. However, the results discussed here clearly indicate that the carbon isotope composition of leaves can be a useful measure of forest dynamics under changing environmental conditions. This study is supported by "The Eco-Technopia 21 Project" from the Ministry of Environment, Korea.

O26

Contributions from belowground respiratory fluxes in an irrigated rice paddy determined by carbon isotopic compositions of ecosystem respiration

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CO_2 efflux from waterlogged soil surface has been often neglected, because the floodwater and water-filled pores form a strong diffusion barrier to release of belowground CO_2. Furthermore, it has been often assumed that belowground (root and soil microbial) respirations are negligible (or negligibly small compared to those under drained conditions) and thus do not contribute to the carbon balance of the ecosystem under flooded conditions. However, other compelling experimental evidences exist that anaerobic decomposition of organic matter (e.g., plant debris and photosynthates released by roots) and production of CO_2 and methane as the end products are the very active processes governing the carbon cycle in the paddy ecosystem. To investigate the contribution from belowground respiratory flux at the ecosystem scale, we periodically measured the carbon isotopic composition of ecosystem respiration (δ_R) by means of Keeling plot in an irrigated Japanese rice paddy, in conjugation with continuous aerodynamic flux measurements of CO_2 and methane (by eddy covariance and flux-gradient methods, respectively).

The observed δ_R increased from –26.3‰ to –23.2‰ over the growing season in 2003 and was strongly correlated with the variations in carbon isotopic composition of bulk leaf and CO_2 entrapped in soil (δ_P and δ_S, respectively). δ_S was gradually enriched in ^{13}C as influenced by the CO_2-dependent methane production pathway ($CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$). Upon floodwater drainage, δ_R increased remarkably by 1.1‰ to 3.1‰ accompanied with large emissions of methane and with increased nighttime NEE (net ecosystem exchange). The results strongly support a significant role of belowground CO_2 flux on the ecosystem carbon exchange, regardless of flooding conditions.

We attempted to quantify the contribution from belowground respiratory flux to the total ecosystem respiration by partitioning ecosystem respiration into plant (above-ground) and soil (belowground) respirations based on δ_R and the carbon isotope ratios of each respiratory component (δ_P and δ_S, respectively). The estimated proportion of soil respiration under flooded conditions was, on average, 32% of the ecosystem respiration and showed a weak seasonal variation. In the early growing season when the rice canopy was still small (LAI = 0.1), soil respiration accounted for about 50% of the ecosystem respiration. In the later flooded periods ($2 \leq LAI \leq 5$), the proportion of soil respiration ranged between 20% and 33%. Under drained conditions, the proportion of soil respiration was estimated to be about 40% of the ecosystem respiration, regardless of the duration of drainage. A simple calculation showed that emission rate of belowground CO_2 increased by 2 to 3 times by the drainage practices. To illustrate the importance of belowground CO_2 processes in the paddy ecosystem, we estimated the temporal variation in NPP (net primary production) from the measured NEP (net ecosystem production), the approximated total ecosystem respirations from air temperatures, the inferred proportions of soil respiration, and the above- and below-ground biomass distributions. The cumulative NEP over the growing season was about 200 g C m^{-2} smaller than the measured biomass carbon increase. There was a good correspondence between the time courses of the estimated NPP and the measured biomass carbon.

O27

CO_2 SINK ASSESSMENTS FOR LONG-TERM MONITERING IN A COOL-TEMPERATE DECIDUOUS FOREST IN KOREA

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Long-term monitoring and accurate measuring the net ecosystem production (NEP) in forest ecosystems are very important to understand the carbon balance under current and future global warming environments.

Our study on carbon sink assessments was based on the forest ecological method in a *Quercus mongolica* forest at Daegwallyeong Flux Measurement Site (DFMS), which is the typical cool-temperate deciduous forest in Korea. We carried out the measurements of biomass, net primary productivity (NPP), soil CO_2 efflux and estimated the net ecosystem productivity (NEP) from August 2003 to August 2005. The biomass and NPP were calculated from results of tree census in each year. The soil CO_2 efflux and heterotrophic respiration were measured with a multichannel automatic chamber system through the whole year.

The biomass was estimated to be 144.5 and 154.1 ton ha^{-1} in 2003 and 2004, respectively. NPP was 4.8 tC ha^{-1} in 2004. Annual total soil respiration and heterotrophic respiration in 2004 was 5.3 and 2.4 C tC ha^{-1}, respectively. NEP of this forest was 2.4 tC ha^{-1} in 2004.

O28

THE ROLE OF CARBON-TO-NITROGEN RATIOS FOR QUANTIFYING CARBON SEQUESTRATION IN CHINA'S SOILS

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Soils may help decrease the threat of global warming by removing greenhouse gases from the atmosphere and using the carbon in those gasses to build soil organic matter. This process is called carbon sequestration. We found that the ratio of carbon to nitrogen in soil organic matter can be used as an index to determine whether soil organic matter is increasing or decreasing. Net accumulation of soil organic carbon in soil is constrained by the amount of soil organic matter and its maximum C:N ratio. Our objectives were to estimate the potential for China's soils to continue sequestration carbon within the soil organic pool. We calculated total soil organic carbon and organic nitrogen in the top meter of 5439 representative soil profiles from the China national second soil survey database. Nitrogen in these mainly forest soils was assumed to be at steady state. The maximum carbon storage capacity was estimated by calculating the amount of carbon stored under assumed maximum soil C:N ratios of either 20,15 or 13. We will discuss the spatial differences of soil carbon sequestration in arid and humid regions in China. The research will benefit land managers who need information on how well their management systems are working and may serve as a tool to help action agencies and policy makers measure the amount of carbon being sequestered in soil organic matter.

***Keywords*:** Soil carbon storage; C:N ratio; Soil nitrogen storage; Carbon sequestration

O29

THE EFFECTS OF SOIL EROSION ON DYNAMICS OF SOIL ORGANIC CARBON AND CO_2 RELEASE

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Soil erosion and deposition influences the accumulation and loss of soil organic carbon (SOC), yet it has not been concerned in the study of soil carbon cycle. In this paper, A typical rolling farmland in Black Soil region of Northeast China was taken as a case to analyze the impact of soil erosion and deposition on the diurnal and seasonal CO_2 flux and the variation of different labile carbon fractions based on measurement of CO_2 flux, water soluble organic carbon (WSOC), microbial biomass carbon (MBC), particulate organic carbon (POC) and macro-aggregate organic carbon (MOC).The results showed that the CO_2 evolved from the soil surface varied significantly among seasons ranging from 0 gC m^{-2} d^{-1} in the winter to about 13.6 gC m^{-2} d^{-1} during the summer. There was no obvious difference for the release of CO_2 between erosion and deposition sites except for shoulder-slope although depositional areas had higher labile fraction content than eroded slope positions. Soil C flux exhibited diurnal variations with high values differing from lows by as much as 0.067 g C m^{-2} h^{-1}. Peak flux rates as high as 0.106 g Cm^{-2} h^{-1} occurred during the mid afternoon during the spring, summer, and autumn seasons. Soil C flux was significantly correlated with soil temperature and air temperature but not with soil moisture content. In addition, soil erosion significantly decreased the content of WSOC, MBC, POC and MOC at eroded geomorphic positions, those of depositional sites such as foot-slope accumulated except for WSOC. The significant positive correlation between each labile carbon fraction and TOC was found. Above preliminary conclusions demonstrated that eroded carbon trapped in deposition positions increased the activity of microorganism and was apt to be mineralized other than be sequestrated in oxidizing environment.

Keywords: Soil erosion and deposition; CO_2 flux; labile organic carbon; black soil

O30

SEVERAL CONSIDERATIONS ON STUDYING CARBON BALANCE OF GLOBAL TERRESTRIAL ECOSYSTEMS.

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To address “missing carbon sink” in global scale is a big challenge for the global change scientists. Although the reported value of missing carbon sink is different in various documented materials, it is usually about 2 Pg C. If the value can be found only in some concentrated areas, for example, as reported in middle latitude areas, the carbon sink in these regions will be unimaginable great and would be easily found and have been well documented. More probable situation may be that the missing carbon sink is more averagely distributed in terrestrial ecosystems and inland water bodies, although there may be some relative high sink areas. If this hypothesis is rational, the carbon sink in normal regions will be less than 0.5 ton$\cdot$ ha$^{-1}\cdot$ yr^{-1}. Under this consideration, precise, long-term and large area of measurement is absolutely necessary, and carbon flux by eddy covariance must be tested by the complexity of other multiple ways due to its unstability of recording and rigorous requirement on flat topography. Furthermore, some processes in which carbon content is low can not be omitted, such as the organic carbon in forest hydrological processes, it may be the best way to show the accumulation of organic carbon in soil, especially in deep soil. When studying carbon balance of global terrestrial ecosystems, another important aspect that we should pay more attention to is comprehensively considering the turnover time and storage change of various carbon pools in terrestrial ecosystems. The organic carbon in the pools has turnover times ranging from months to millennia, with much of it around several years to a few decades.

Key words: Carbon missing sink, Tentative distribution pattern, Measurement ways, Hydrological processes, Turnover time

O31

Carbon dioxide flux of three ecosystems on the Tibetan Plateau.

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Abstract: Grassland ecosystem provides a wide range of environment service function and plays an integral part in the life supporting-system. Tibet plateau is a unique geogranfic unit with a vast territory, high attitude, cold air temperature, strong sonar radiation, and typical alpine ecosystems. Alpine meadow，alpine shrub and alpine swamp ecosystems are widely distributed on the plateau and they are characterized by short growing period, high soil carbon content and sensitive to global warming. Alpine meadow dominated by *Kobresia humilis* and various grasses and forbs (depending on grazing density) are distributed in this region along the valley floor. The shrub, *Potentilla fruticosa* are joined by shrubby *Salix* species are locating on the north hill. The region swamp vegetation consists primarily of *Kobresia tibetica* and *Pedicularis longiflora.* Sheep and yaks, the major herbivorous animals in the region, live on herbage, which varies greatly with seasons. The eddy covariance method was employed to measure the CO_2 exchange between the atmosphere and alpine meadow, alpine shrub land and alpine swamp ecosystems in northeastern Tibetan plateau from November 2002 to October 2003. Results from the first year indicated that net CO_2 fluxes were carbon sink for alpine meadow, shrubland but weakly sources for swamp ecosystem on Northeastern Tibetan Plateau. Corresponding daily CO_2 fluxes were 2.36, 1.67, and 2.07 g CO_2 sink of growing season from May to October, and 1.35, 1.18, 2.19 g CO_2 sources of non-growing season from November to April of next year for meadow, shrubland and swamp ecosystems respectively. The temperature sensitivity of ecosystem CO_2 emission (Q_{10}), was estimated to be 2.73, 5.06 and 15.15 for the alpine meadow, shrubland and swamp ecosystems, respectively. The high Q_{10} for the swamp ecosystem seems due to the high organic matter and large proportion of belowground biomass as well. The results indicate that the swamp would have larger potential of ecosystem CO_2 emission than the other two alpine ecosystems. The high Q_{10} for the swamp ecosystem seems due to the high organic matter and large proportion of belowground biomass as well. The current study suggests that the Qinghai-Tibetan Plateau could be a significant CO_2 source during the no-growing season and it has significantly contribution on annual CO_2 flux.

O32

Seasonal Variations in Energy and CO2 Fluxes over a Cropland Surface in north China

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The direct and indirect effects of increasing atmospheric CO_2 may have profound implications for the structure and function of plant communities. Vegetation, in turn, plays a crucial role in the global carbon balance. Climate simulations are especially sensitive to the surface partitioning of available energy into sensible and latent heat fluxes. Agricultural ecosystem is one of the most widespread vegetation types in the world and therefore is a significant component of the earth's climate system. Field studies designed to characterize land surface processes in agricultural ecosystem are thus needed. We report results obtained from one year of an ongoing measurement campaign that quantifies the land surface-atmosphere exchanges of carbon dioxide, water, and energy over a cropland surface in the agricultural ecosystem in north China. Eddy covariance flux measurements have been making at the height of 16 m in a regular meteorological station (39.22N, 115.72W) since May, 2004. Ancillary measurements include radiation budget, meteorology, and soil moisture and temperature. The site is typical of plains in north China. Within the experimental period, the dominant temporal variation in fluxes of carbon, water, and energy are caused by variations of crop (winter wheat and corn) growth. Based on footprint analysis, we expect >90% of the measured flux to occur within the nearest 10 km of upwind area. We examine seasonal and diurnal variations in the components of the surface energy balance and in CO_2 flux. Results show that significant variation occurred in surface energy partition and CO_2 during the experiments. Daytime absorption of CO_2 flux by the crop canopy increases when latent heat flux increases. We examined the energy budget closure and found it ranges from 0.6 to 0.9.

O33

The carbon dioxide exchange over a typical steppe in Inner Mongolia, China

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Introduction

Typical steppe ecosystems developed under semi-arid continental temperate climate condition cover approximately 4.1×10^7 hm^2 that is about 10.5% of the national grassland area. Recent study shown the climate change in this region has been getting warmer trendy accompanied with obvious increasing air temperature in winter and serious drought in spring. Therefore, there is a virtual need for long-term field measurements to quantify carbon dynamics under climatic changes condition and management practices.

The experimental site is at Inner Mongolia Grassland Ecosystem Research Station located at Xilin River Water- shed of Inner Mongolia Autonomous Region (43 ° 32 ′N , 116 ° 40 ′E, 1200m a.s.l.). The site has been fenced for 24 years since 1979, being distant from settlements and water holes, the center of the research of Global Change and NECT. The climate is described as semi-arid continental temperate steppe with a dry spring and moist summer. Annual temperature averages - 0. 4 ℃ with a plant growth season of 150 - 180 d. The annual precipitation range is 320 - 400 mm, but is mainly concentrated in June to August. There are many litter falls on the ground.

Methods

Wind speed, temperature, CO_2, and air temperature were measured at 2 m over ground level. Vertical wind speed and temperature fluctuations were measured at 10 Hz using a three-dimensional sonic anemometer-thermometer aligned into the mean wind. Carbon dioxide and H_2O vapor fluctuations were measured at 10 Hz with a fast response open-path infrared gas analyzer.

Results

1. Diurnal course of CO_2 flux

During the study period in two years, the diurnal CO_2 flux pattern was divided into two situations. One had dual uptake peaks that after sunrise (at 6:00 am, Beijing Standard Time), grassland began to take up CO_2 (F_{CO2} was negative) and F_{CO2} reached the daily maximum magnitude at 8:00; then gradually decreased as PAR increased until became positive (i.e. emission) at 11:00. F_{CO2} became negative at 16:30 again. After sunset at 19:00, the grassland kept the emission of CO_2 and became a net source of CO_2.

Another diurnal course of CO_2 flux was only single peak of uptake. In 2003, the grassland started to take up CO_2 around 6:00~6:30. After reaching the maximum uptake about 8:00, F_{CO2} gradually decrease until became a net source of CO_2 around 19:00~20:00. In contrast, in 2004 the ecosystem began to take up CO_2 around 8:00 and reached its maximum magnitude around 10:00 as PAR increased. Subsequently the uptake gradually decreased with the progress of PAR, and the grassland began to become the net source of CO_2 around 20:00 (i.e. F_{co2} was positive).

In addition, in order to investigate the relationship between PAR and F_{CO2}, we plotted the F_{CO2} against PAR. After sun rising the magnitude of F_{CO2} increased as PAR increased every month and reached the maximum value around 600~800 μ mol $m^{-2}s^{-1}$and 1000 μ mol $m^{-2}s^{-1}$ respectively in 2003 and 2004. At the same level of PAR, the afternoon F_{CO2} magnitudes were smaller than those in the forenoon. In particularly in 2004, the difference between afternoon and forenoon magnitudes was bigger than that in 2003.

2. Seasonal variation of CO_2 flux

The daytime fluxes of CO_2 ranged from an uptake of -3.5 g $m^{-2}d^{-1}$ for the month of July to an emission about 2.8 g $m^{-2}d^{-1}$ in May during this study period in 2003. The maximum uptake and release was -6.6 g $m^{-2}d^{-1}$ in August and 3.1 g $m^{-2}d^{-1}$ in May respectively in 2004. By mid May in 2003, the grassland began to uptake CO_2 the peak value time was in Mid-June through Mid-July. Until late September, the signal fell into positive that indicated grassland began to release CO_2. In 2004, grassland began to uptake CO_2 at early June, the peak value appeared in August, and released CO_2 until late September. Through integrating half-hour night F_{CO2} magnitude, we found that the grassland released more CO_2 comparable at night during this study period. In 2003, the magnitude of night CO_2 flux (Re) reached the maximum value 4.4 g m^{-2} d^{-1} in July. In contrast, in 2004, the value 4.5 g $m^{-2}d^{-1}$ t was observed in August.

Calculating the sum of diurnal and nighttime F_{CO2}, and then integrated the daily sum to one month. The variation in monthly CO_2 fluxes was considerable distinction from May to September between 2003 and 2004. In 2003, the magnitude of maximum monthly CO_2 uptake -135.36 g $m^{-2}mon^{-1}$ was observed in June. However, the maximum emission 95.2g m^{-2} mon^{-1} exhibited in July. In contrast, there was a maximum uptake -244.26 g m^{-2} mon^{-1} and emission 121.37 g m^{-2} mon^{-1} in August of 2004. Grassland started to become a net sink of carbon dioxide in June and reached the maximum value during growing season in 2003. However, in 2004, the date of conversing is in July, delayed near one month than 2003's.

3. Depression of net ecosystem CO_2 exchange

This study found that there was an evident decrease at midday (F_{CO2} is positive) during the study period of two growing seasons. This phenomenon cannot simply attribute to midday photosynthesis depression although the photosynthesis decrease can cause the ability of fixing CO_2 decline at midday. We entitle "Ecosystem Midday Decrease" for this phenomenon. When the ecosystem respiration over the vegetation photosynthesis also causes the positive F_{CO2} Besides this situation, we found also that during this study period CO_2 flux did not increase with PAR increased and its maximum value was not consistent with the maximum PAR. However, at midday F_{CO2} still maintain negative

Conclusions

Comparably, the characteristics of carbon dioxide exchange at our sit are totally difference with other grasslands in the world. Except the magnitude and tend variability of CO_2 uptake, the most distinct difference is that the grassland displayed double peaks of CO_2 uptake, i.e. there was an "Ecosystem midday decrease" phenomenon at midday.

O34

RESPONSES OF TRANSPIRATION AND CANOPY CONDUCTANCE OF YOUNG CONIDFEROUS PLANTATION TO SEVERE DROUGHT IN SOUTH CHINA

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A two-year measurement (2003-2004) of evapotranspiration (LE) and its components were made in a coniferous plantation in south China. This ecosystem was experienced a prolonged dry spell and above-normal temperatures during July 2003. During this episode, total precipitation was less than 5 mm, and the temperature was higher 3 ℃ than the average level. LE was measured continuously with eddy-correlation systems from a 42.5 m tower, and transpiration (Tr) was measured by thermal-dissipation sapflow technique in six different trees. Canopy conductance (Gc) was estimated from the sap flux measurement using the inversed Penman-Monteith equation. The results showed that for this young coniferous plantation, the difference of the canopy conductance value was significant in different water conditions. The canopy conductance linearly increased with drought index. Moreover the long-term no-rain weather caused the peak value of daytime Gc to occur earlier in the morning. The weight of transpiration and understory evaporation (Es) to the total evapotranspriation varied with the climate condition, and the ration of Es to Tr increased decreased with drought index. There was sensitive response of Gc to environmental factors under no water stress and ample water conditions, but it was relative conservative under severe drought condition.

Keywords: Drought; Canopy conductance; Transpiration; Evapotranspiration; Coniferous forest

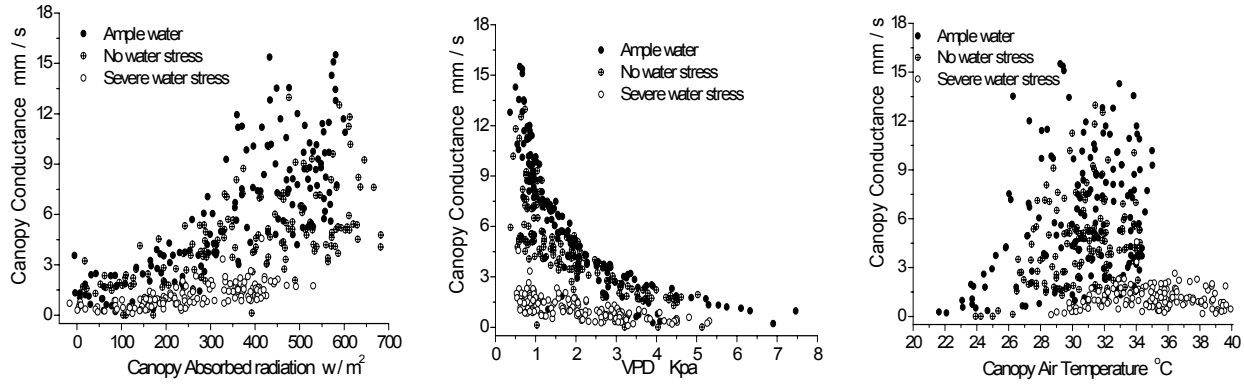

Fig. Response of Gc to environmental factors under different water conditions

O35

SURFACE ENERGY FLUXES OF THE TIDAL ZONE OVER THE ARIAKE SEA

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The Ariake Sea is a closed bay on the west of Kyushu Island, Japan, with a dynamic tidal range over 5 m in the closed-off section of bay in the spring tide. The Ariake Sea also has a vast tidal flat: the exposed area becomes wider than 200 km^2 in the spring tide, occupying about 40 % of the total exposed area in Japan.

The energy budget on the tidal flat surface has been thought to play an important role in controlling the thermodynamic properties of seawater and the biophysical chemical processes of the tidal bottom surface. However, the land sea surface-atmosphere interaction on the tidal flat is complicated because of including not only the diurnal cycle mainly driven by solar radiation but also the tidal cycle controlling the seawater coverage in the tidal bottom surface. Therefore, the objective of this study is to observe the surface energy fluxes on the tidal flat using the direct method of turbulent eddy correlation.

The observation system was constructed on the inter-tidal zone near the Kumamoto Port (32º46´5" N, 130º35´40" E). The turbulent flux observation system of the AWS is composed of the sonic anemo-thermometer (81000, YONG) and the infrared H_2O/CO_2 gas analyzer (LI-7500, Li-COR). The data are sampled at 10 Hz and stored on the data logger (CR-5000, Campbell). The surface around the system exposes offward about 1.5 km at lowest water level. Around site, the bottom surface exposes as long as 3.5 hours in a half-day tidal cycle in the spring tide. In the neap tide, however, the bottom surface is always submerged.

While the bottom surface was submerged in the daytime, the sensible heat flux and latent heat flux was as low as 100 Wm^{-2}, although the net radiation flux became higher than 700 Wm^{-2}. As soon as the bottom surface was exposed, both the sensible heat flux and the latent heat flux increased because the bottom soil surface was heated directly by the net radiation. Under the exposed condition, the bottom soil was still wet and the latent heat flux was dominant. During several hours from sunset, the latent heat flux became higher than 150 Wm^{-2}. The diurnal variation of the water temperature, skin surface temperature, and atmospheric temperature showed that the atmospheric stratification was still unstable during the night with the bottom surface covered by seawater, which released the heat energy both into atmosphere and into the bottom soil.

A scale analysis of seawater temperature equation showed that vertically integrated advection term became an order of 100~500 Wm^{-2}, by substituting the typical value in the Ariake Sea. This value was comparable to other components of the surface energy fluxes.

O36

APPLICATIONS OF GENETIC NEURAL NETWORK MODELS FOR GAP-FILLING OF CO_2 FLUX DATA SETS

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In continuous measurements of flux, about a quarter to almost a half of data is commonly missed. Many gap-filling methods have been proposed; lookup-table and mean diurnal variation methods, multiple imputation method, empirical equations parameterized by the non-linear regression (NR) and artificial neural network (ANN) method.

At first, we proposed two new gap-filling methods; an ANN designed by genetic algorithm (GA) - **GNN** (genetic neural network) method, and a multiple GNN model, in which data are classified by a self-organized map (SOM; Kohonen, 1995: *Self-Organizing Maps*, Springer-Verlag, pp. 362) - **SOM-GNN** method. When an ANN model is applied for NEE gap-filling, there are some difficulties in selection and determination of the input elements and model parameters. In the GNN method, GA, which is one of optimization methods, selects effective input elements from the data sets and determines parameters automatically (Fig. 1a). However, calculation time of GNN methods is not short, therefore we tried to reduce the calculation cost by SOM-classifying input data and preparing a specialized GNN model for each data class (Fig. 1b). It is different from conventional classification (e.g. cluster analysis) that SOM is a non-linear method and has a topological conservation of input vector data. In this study, these classes may imply differences in phenology and meteorological conditions. In the SOM-GNN method, a GNN model used only one data class, so that it can save calculation time by preventing over-fitting of the model to other data classes. Additionally, for rapid calculation, ANN-design (chromosome) in each a chromosome pool in a GNN are exchanged among the pools in adjacent GNN models whose classes were topologically near in the SOM, according to probability and varieties of chromosome in the pools.

Secondly, we evaluated the performance of the NR, ANN, GNN and SOM-GNN methods for the gap-filling of NEE data sets measured at a Japanese larch plantation (Tomakomai, Hokkaido: Site T), a Japanese red pine forest (Miki, Hyogo: Site M) and a Siberian larch forest (Neleger, Yakutsk: Site N). For site T (May to September 2002). Determination coefficients (r^2) of the ANN models between observed and estimated values of NEE were almost same as that of the NR method (r^2=0.86). Performance of the GNN and SOM-GNN was somewhat higher. For sites M (September 2004 to July 2005), the GNN and SOM-GNN methods also indicated favorable performance compared to the NR method.

From these results, it was suggested that the proposed neural network methods are powerful tools for gap-filing and have high availability because they do not require special knowledge about the mechanisms of target systems. In addition, this study demonstrated a data-oriented modeling supported by adaptive computation, which is consistent with a change in the paradigm of developing biospheric models more constrained from with observational data.

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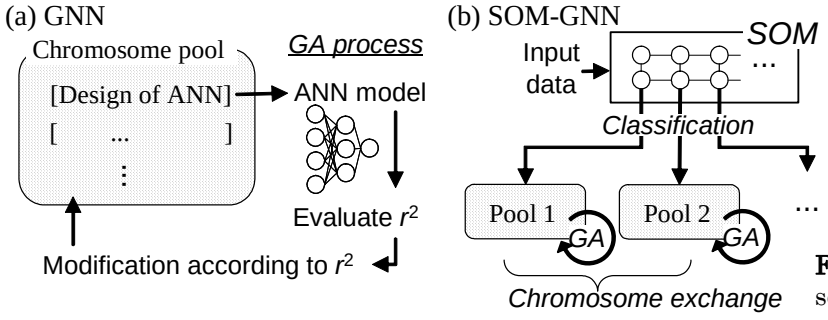

Fig. 1 Diagrams of the GNN method and self-organized map (SOM)-GNN method

Table 1 Example of determination coefficients (r^2) at site T and M

	NR	ANN	GNN	SOM-GNN
T	0.86	0.85	0.88	0.87
M	0.79	0.67	0.81	0.80

O41

RECTIFIER EFFECT IN AN ATMOSPHERIC MODEL WITH DAILY BIOSPHERIC FLUXES

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Inversion studies (e.g. Gurney et al. 2002) showed that an important uncertainty in the flux estimates is the interaction between the atmosphere and the biospheric fluxes or the 'rectifier effect'. Recent studies have shown that supplementing the baseline flask CO_2 data with continuous CO_2 measurements at baseline and continental sites could yield inversion results with greater spatial/temporal resolutions. However, continuous CO_2 measurements at continental sites show strong interaction between the atmospheric mixing and the biospheric fluxes on many time scales including diurnal, synoptic and seasonal time scales. The synoptic scale interaction is the subject of this study.

This study investigates the atmosphere-biosphere interaction on the synoptic time scale using the Biome-BGC (Thornton et al., 2002) and NIES (National Institute of Environmental studies) transport models (Maksyutov and Inoue, 2000) We used two global biospheric source distributions from Biome-BGC. One represents the daily fluxes with Biome-BGC driven by NCEP (National Centers of Environmental Prediction) daily averaged data from 1990 to 1999 (the fluxes for each year were adjusted to yield a neutral biosphere), and the second source distribution is the mean monthly fluxes averaged from year 1990 to 1999 (used as the reference in this study). These biospheric fluxes were then transported in the NIES transport model with NCEP wind data from year 1990 to 1999. Thus the biospheric flux and transport are consistent as they both used the NCEP meteorological data. The difference in the atmospheric CO_2 concentration produced by these two source distributions represents the effect of coupling between the atmosphere and biosphere with daily variations in the biospheric fluxes.

We have found that the magnitude of the difference in CO_2 simulated by the model by these two sources is approximately 10 ppm near the surface. These variations are comparable to the mean seasonal cycle. The anomalies are typically centred over landmasses and have length scale of ~500-1000 km with little continuity over different months. The smaller scale features have shorter lifetime (~ 1 month). The annually averaged CO_2 difference is about one order of magnitude smaller while still showing large interannual variations and similar spatial features.

These results show that the synoptic scale rectifier effect on the CO_2 concentration is significant on the monthly timescale and has some effect on the annual time scale. Thus the synoptic scale rectifier effect may contribute to the errors and uncertainties of CO_2 inversion estimates by models without the synoptic scale interaction of the atmosphere and biosphere.

O42

Eco-hydrological modeling and remote sensing for monitoring carbon and water fluxes in topographically complex forested landscapes

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MODIS (Moderate Resolution Image Spectrometer) is a core satellite sensor boarded on Terra and Aqua satellite of NASA Earth Observing System since 1999 and 2001, respectively. MODIS vegetation products (e.g. LAI, GPP, and ET) provide useful tools for monitoring seasonal variations of terrestrial carbon and water fluxes. For the reliable application of MODIS products, extensive validation efforts need to be addressed for diverse ecosystem regimes. We evaluated uncertainties in MODIS FPAR, LAI, and GPP products with respects to cloud contamination, input meteorology, and parameterization in Korea. The cloud-originated errors were 8.5%, 13.1%, and 8.4% for FPAR, LAI, and GPP, respectively. Summertime errors from June to September explained by 78% of the annual accumulative errors in GPP, which indicates that cloud-originated errors should be mitigated for practical use of MODIS vegetation products to monitor seasonal and annual changes in plant phenology and vegetation production in Korea. MODIS GPP algorithm adopts Data Assimilation Office (DAO) meteorological data to calculate daily GPP. By evaluating the reliability of DAO data with respect to surface weather station data, we examined the effect of errors from DAO data on MODIS GPP estimation in Korea. DAO data resulted in overestimation of GPP by 25% for most of biome types but up to 40% for forest biomes that is major biome types in Korea. MODIS GPP was more sensitive to errors in shortwave radiation and VPD than air temperatures. Our results indicate that more reliable gridded meteorological data than DAO data are necessary to better estimate MODIS GPP in Korea. Finally, we applied eco-hydrological models (BIGFOOT and RHHESSys) to evaluate uncertainty in MODIS GPP parameterization. The models were validated by using NPP data which was estimated from dendrochronological data and then, applied to calculate maximum light use efficiency(ε_{max}), a core biophysical parameter in MODIS GPP algorithm, which showed 30% underestimation of the MODIS GPP default parameter. Overall, our research indicates that considerable uncertainties were imbedded in MODIS vegetation products and hence, special concerns to mitigate the uncertainties are required for regional application of MODIS vegetation products.

O43

AN EVALUATION OF CO_2 FLUX AND LATENT HEAT FLUX IN OPEN CANOPIES WITH A MODIFIED SOIL-PLANT-ATMOSPHERE MODEL

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This study evaluates the prediction of diurnal variation of moisture and carbon dioxide flux from a modified soil-plant-atmosphere model with eddy correlation data collected above a pine forest located in a semiarid environment in central Oregon.

The model is based on the canopy model (soil plant atmosphere (SPA) model) of Williams et al., (1996), coupled to a multi-layer soil model with snow and frozen soil physics (Koren et al., 1999). In the canopy model, plants are assumed to open their stomata until either (1) further opening does not constitute an effective use of stored water in terms of carbon gain per unit water loss, or (2) further opening causes a drop in leaf water potential below the limit that causes xylem cavitation (Williams et al., 1996). In modified SPA model, we reduced vegetation layers from 10 layers to 2 layers for use in large-scale model and included stem effect in leaf energy balance. And also subcanopy eddy diffusivity was incorporated to calculate air temperature and mixing ratio in the subcanopy. Estimates of NEE were calculated as the sum of GPP from model simulation and estimates of respiration of ecosystem (R_e) determined from empirical temperature response equations.

Simulations were carried out for June and July during growing season in 2003. In June, soil water stress was relatively low and vapor pressure deficiency was moderate while in July both soil water stress and vapor pressure deficiency were high. The model showed an overall good performance in simulating the variability of half hourly latent heat flux and NEE, explaining 78% and 87 % of the variance, respectively. Two cases were selected to examine the impact of soil moisture deficit on diurnal variation of carbon dioxide and water vapor fluxes. The first case contained data for the period between days 152 and 181 when soil moisture was ample. The second case contained data between days 197 and 212. At this time, both soil moisture deficit and air temperatures were high. The model reproduced mean diurnal variation of latent and sensible heat flux and net ecosystem exchange when soil moisture was ample. In case 2, the model predicted reasonably the diurnal course of latent heat flux and CO_2 flux but it overestimated the turbulent fluxes in the morning and showed an earlier peak of carbon uptake compared to the measured CO_2 flux. Compared to case 1, case 2 had many calm nights and mornings with weak turbulence. The overestimation of the turbulent fluxes was related to the large energy imbalance in observations mainly due to weak turbulent intensity. The earlier peak of carbon uptake was due to neglected CO_2 storage term in model. However, the CO_2 storage did not explain the overestimation of respiration throughout the night, suggesting that other process such as drainage flow could play a role in carbon budget during calm night at this site.

O44

A COMPARISON BETWEEN MODELED AND MEASURED CO_2 AND WATER VAPOR FLUX IN A SUB-TROPICAL CONIFEROUS FOREST

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Abstract: Using data from eddy covariance measurements in a subtropical coniferous forest, we tested and evaluated the model of **C**arbon **E**xchange in the **V**egetation-**S**oil-**A**tmosphere (CEVSA) that simulates energy transfers and water, carbon and nitrogen cycles based on eco-physiological processes. In the present study, we improved the model in calculating LAI, carbon allocation among plant organs, litterfall, decomposition and evapotranspiration, and tested and validated the model. The modeled seasonal variations in carbon and water vapor flux were consistent with the measurements. The model explained 79% and 86% of the measured variations in evapotranspiration and soil water content. However, the modeled evapotranspiration and soil water content were lower than the measured systematically, because the model assumed that water was lost as runoff if it was beyond the soil saturation water content, but the soil at the flux site with abundant rainfall is often above water saturated. The model reproduced 79% and 88% of the measured variations in gross primary production (*GPP)* and ecosystem respiration (R_e), but only 31% of the variations in measured net ecosystem exchange (*NEP*) although the model annual NEP was close to the measured. The modeled *NEP* was generally lower in winter and higher in summer than the measured. The modeled responses of photosynthesis and respiration to water vapor deficit at high temperatures were different from measured, and the model underestimated ecosystem photosynthesis and respiration in extremely condition. The present study shows that CEVSA can simulate the seasonal pattern and magnitude of CO_2 and water vapor fluxes, but it requires improvement in simulating photosynthesis and respiration at extreme temperatures and water vapor deficit.

***Key words*:** Ecosystem CO_2 and water vapor flux, CEVSA, eddy covariance, subtropical coniferous forest.

O45

Simulation of CO2 flux in three different ecosystem in ChinaFLUX based on artificial neural networks

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The non-linearity of the relationship between CO2 flux and other micrometeorological variables flux parameters limits the applicability of carbon flux models to accurately estimate the flux dynamics . but the need for Carbon dioxide(CO2) estimations covering larger areas and the limitations of the point eddy covariance technique to address this requirement necessitates the modeling of CO2 flux from other micrometeorological variables. Artificial neural network (ANN) are used because of their power to fit highly non-linear relations between input and output-variables without to explain the nature of the phenomena. In this paper ,we applied a multilayer perceptron ANN technique with error back propagation algorithm to simulate CO2 flux on three different ecosystems (forest, grassland and maize) in ChinaFLUX . Energy flux(net radiation, latent heat, sensible heat and soil heat flux) and temperature (air and soil) and soil moisture were used to train the ANN and predict the CO2 flux . Diurnal half-hourly fluxes data from June to August of observations in 2003 were divided into training , validating and testing. Results of the CO2 flux simulation show that the technique can successfully predict the observed values with R2 value between 0.75 and 0.866. The results also showed the soil moisture couldn't improve the simulative accuracy without limitations of soil moisture. The analysis of the contribution of input variables in ANN show the ANN is not a black box model, it can tell us about the controlling parameters of NEE in different ecosystem and micrometeorological environment. The results indicate the ANN is not only the reliable ,efficient technique to estimate regional or global CO2 flux from point measurements and understand the spatiotemporal budget of the CO2 fluxes ,but also can discovery the relations between the CO2 flux and micrometeorological variables.

***Keywords*:** Artificial neural network;CO2;ChinaFLUX; Energy flux; variables contribution.

O46

ANALYSIS AND INTERPRETATION OF ASIAFLUX DATA IN CONNECTION TO GLOBAL CARBON CYCLE MODELING

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A regional carbon sink is a sum of carbon fluxes provided by regional ecosystems. The combinations of ecosystems, environmental and climate conditions form a variety that developing network for carbon flux monitoring cannot cover, and so the regional and global assessments are presumed to be based on models extrapolating and interpolating measured fluxes.

Getting robust estimate of regional carbon sink is a challenge. Not every model that fit fluxes measured at a site may serve the purpose. If accuracy achieved by model specialization, that is, by taking into account specific features of the site, the model is hardly applicable at regional scale, across the ecosystem diversity.

TsuBiMo (a process-based carbon cycle model) was developed for applying at the regional and global scale, and therefore it employs only those biophysical concepts that are commonly applicable. One of them is optimal temperature of photosynthesis. The temperature dependence of light-saturated photosynthesis is commonly drawn as a bell-shaped curve that peaks somewhere between 20 and 30°C. The width and height of the "bell" as well as the position of its center depends on plant species and conditions at which plant was grown. The problem is to find values at which corresponding parameters should be set in a global scale model.

With this in mind we consider the AsiaFlux data as indirect measurements of light-saturated photosynthesis, derive its rate by inverting the model of productivity (see [1-2] for details of the method), and plot against temperature. Thus interpreted data provide valuable information about temperature dependence of light-saturated photosynthesis that currently presents a "bottleneck" in modeling climate feedbacks from terrestrial ecosystems. The position of optimal temperature dictates when and where carbon sinks switch to sources under given global warming scenario, and thus current uncertainty in positioning the optimal temperature is a cause of discrepancies in carbon sink assessments [3].

Here we present the results of analysis and interpretation of the data from Takayama [4] and Tomakomai [5] sites of AsiaFlux network and discuss some peculiarities in the obtained curves of temperature response that cannot be readily interpreted within the framework of chemical thermodynamics.

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Poster Session

P01

Leaf phenology model based on seasonal carbon allocation for a forest ecosystems model.

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Abstract

We proposed a new phenological model in which we utilize the amount of carbon stored during the previous late-growth season as the determinate index of the leaf amount built in the following spring, together with several phenological events that have been considered in previous researches of phenology models; i.e., the timings of budburst and leaf-fall, the time series of the increment leaf amount during the growing season and of the decrement until completion of the entire leaf-fall of the stand. Further, our phenological model was coupled with a forest ecosystems model to describe the dynamics of a forest stand. The combined model was applied to a deciduous *Larix kaempferi* forest stand, and the validity of the representation of the dynamics in the stand over seven years was examined. As the outcome of the adjustment of the model parameters along with inventory data obtained at the study site, simulated annual variations of the size-structure and total canopy biomass, canopy averaged diameter and tree height of *L. kaempferi* were quite consistent with outputs derived from observed data (Fig.1). In addition, a simulated annual estimation of NPP (net primary production) agreed well with that by an alternative approach based on field data (Kurachi *et al*., 1993)(Fig.2). Thus, the simulation showed the importance of determining the annual variation of total leaf amount for applying the forest ecosystems model to forest stands with deciduous plant species, by considering the seasonal carbon utilization of trees.

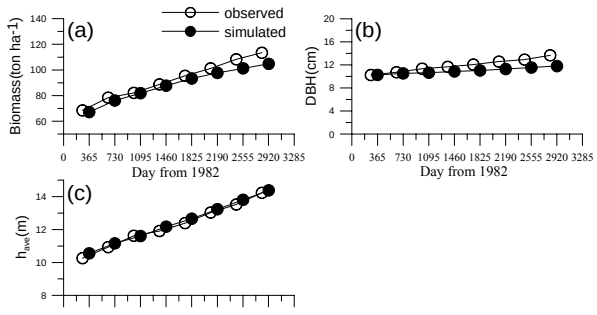

Fig. 1 Observed and simulated annual variations of (a) the entire forest biomass(ton ha^{-1}), (b) stem diameter at breast height (D_{BH})(cm) and (c) averaged tree height (h_{ave}) (m).

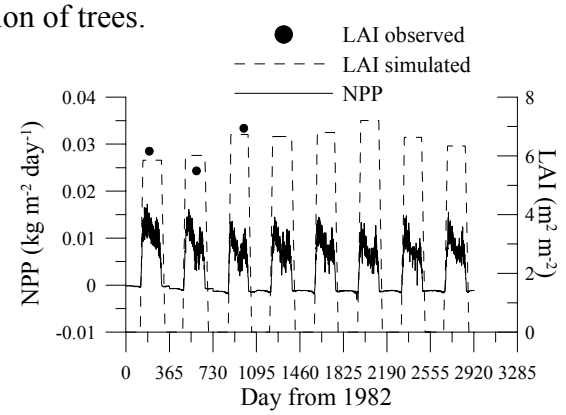

Fig. 2 Seasonal and annual variations of net primary production (NPP) and LAI. The 3-year LAI measured from 1982 to 1984 is plotted.

P02

SEASONAL VARIATION IN LEAF PROPERTIES AND ECOSYSTEM CARBON BUDGET IN A COOL-TEMPERATE DECIDUOUS BROAD-LEAF FOREST: SIMULATION ANALYSIS AT TAKAYAMA SITE, JAPAN

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Temporal variations in the net ecosystem exchange (NEE) of CO_2 over terrestrial ecosystem are regulated by various factors such as environmental conditions and plant phenology. Process-based models, which simulate photosynthetic uptake and respiratory release explicitly, are effective for analyzing the mechanisms of the temporal NEE variations. We have developed an ecophysiological process-based model, which is applicable to flux measurement site, and in this study applied it to assess the effect of another factor, *i.e.* temporal change in leaf properties or leaf aging from emergence to senescence. The carbon cycle model is composed of 12 compartments for four sectors: canopy trees, understory plants, dead biomass (litter), and mineral soil. Net ecosystem production (NEP, = –NEE) is obtained as the difference between gross primary production (GPP) and ecosystem respiration (ER). To simulate carbon budget from diurnal to decadal time scales, the model consists of two modules, one for the 1-day-step ecosystem carbon dynamics and another for the 30-min-step canopy net CO_2 exchange. Leaf phenology is simulated in the 1-day module, using cumulative temperatures to determine leaf emergence and shedding times. The 30-min-step module adopts a sun/shade canopy radiation transfer and photosynthetic scheme developed by de Pury and Farquhar (1997). A series of model simulations were performed at a cool-temperate deciduous broad-leaved forest in Takayama, central Japan, where long-term continuous measurements of NEE with the eddy-covariance method and ecological surveys have been carried out by the National Institute of Advanced Industrial Science and Gifu University. Observational data of leaf area and gas exchange were used to parameterize the temporal change in leaf properties of canopy species, *Betula* and *Quercus*: leaf mass per area (LMA), maximum carboxylation rate (V_{cmax}), electron transport rate (J_{max}), and dark respiration rate (R_d). We conducted a sensitivity analysis by comparing with simulations using constant parameter values (i.e., no leaf aging effect). At first, we examined model reliability with observational data in terms of the carbon cycle such as biomass, soil carbon stock, and annual GPP, ER, and NEP. The estimated NEP was well correlated with the observed NEE (r^2 = 0.85) in 1999 and 2000, suggesting validity of the model. The model reasonably simulated the seasonal NEE change from 3 g C m^{-2} day^{-1} net source in late winter to 5 g C m^{-2} day^{-1} net sink in early to mid-summer (Fig. 1). The sensitivity experiments, in which leaf phenology and/or leaf aging were neglected, showed that sole environmental variation was not sufficient to account for the evident NEP seasonality, and that the leaf aging effect was one of the important factors. For example, neglecting the leaf aging effect, the model overestimated annual GPP by 6% and annual NEP by 38%. Detailed analyses indicated that the temporal change in V_{cmax} was firstly and those in LMA and R_d were secondarily important.

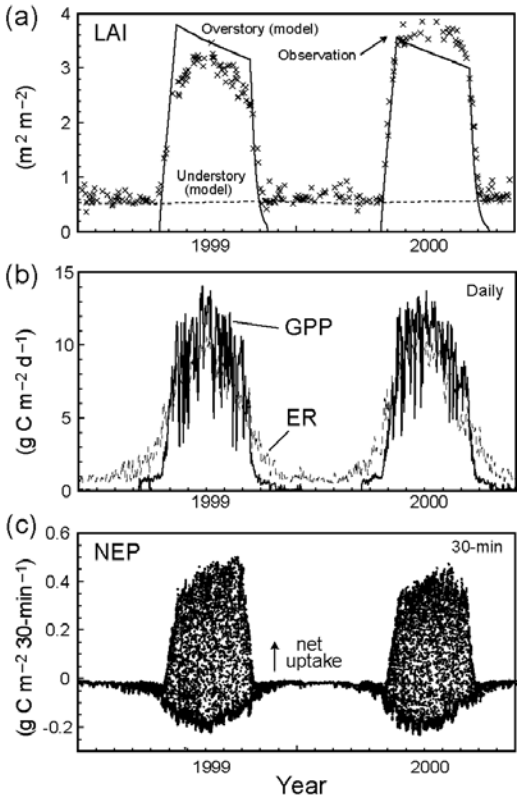

Fig. 1. Seasonal changes in the carbon cycle of Takayama site estimated with a process-based model including the leaf aging effect. (a) Leaf area index (LAI), compared with observation, (b) daily gross primary production (GPP) and ecosystem respiration (ER), and (c) net ecosystem production at 30-min time step.

P03

ESTIMATION OF PLANT AREA INDEX BY DOWN-LOOKING HELIBORNE LIDAR IN JAPANESE LARCH FOREST

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The distribution of leaf area and wood area in forest play an important role in estimation of CO_2 fixation of forest and interpretation of spectral reflectance on remote sensing data. As the indices that express the distribution, a plant area index (PAI), which is the total one-sided leaf area and wood surface area per unit ground surface area, and an average plant inclination angle (APIA), which is the angle between the normal of leaf and wood surface and the vertical, are widely used. Among the many techniques to measure PAI and APIA, gap fraction theory is applied to various applications, because it can measure PAI and APIA without destruction of forest and time-consuming. We developed the techniques to measure gap fraction from the probability of penetration of laser beams through the canopy by the laser range finder (Takeda, 2005). The advantages of using the laser range finder are that, 1) the three-dimensional distribution of PAI and APIA can be measured, 2) the measurement at night time become possible, and 3) the measurement not only at the forest floor but also above the canopy become possible. In relation to 3), we succeeded in the measurement of PAI and APIA in large scale by using side-looking LIDAR mounted on helicopter. However, the commonly used airborne or heliborne LIDAR can not shot the laser beam in the direction of the angle needed to invert PAI and APIA from gap fraction. So, as one attempt to estimate PAI by commonly used heliborne LIDAR, we discussed that the technique to estimate PAI by down-looking heliborne LIDAR, under the assumption that APIA was already known.

The measurement was conducted at the Tomakomai Flux Research Site (hereafter refer to TFRS) in the national forest located in Tomakomai, Hokkaido, Japan (42° 44′ N、141° 31′ E). In TFRS, 45-year-old Japanese larch (*Larix kaempferi* Sarg.) with the tree height of 13.8m (range from 7.0m to 20.0m) was planted and the population was about 1087 plants/ha^{-1}. In order to estimate PAI, dividing the area scanned by down-looking heliborne LIDAR into 63 plots with the area of 100m × 100m, and the measurement of gap fraction in each plot was conducted. To verify accuracy, the measurement of PAI and APIA by side-looking heliborne LIDAR was also conducted in same plots. The measurement of side-looking heliborne LIDAR was conducted in September 8, 2003 and down-looking heliborne LIDAR was conducted in September 9, in 2003.

In a case that APIA assumed 57.3 degree, which is the APIA of spherical distribution, the relation of PAI measured by side-looking heliborne LIADR and down-looking heliborne LIDAR shows that RMSE is 2.21 and the slope of regression line is 1.11. On the other hand, in a case that APIA assumed 45.5 degree, which is the averaged APIA in all plots measured by side-looking heliborne LIDAR, the relation of PAI measured by side-looking heliborne LIADR and down-looking heliborne LIDAR shows that RMSE is 1.84 and the slope of regression line is 0.94. A difference was few seen in RMSE between both PAIs. But, from the result that RMSE was about 2, it was suggested that the error included in PAI could not be neglected in some plots.

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P04

DEVELOPMENT OF MEASUREMENT SYSTEM FOR EVALUATING FOREST ECOSYSTEMS: MEASUREMENT METHOD OF NPP BY USING AIRBORNE LASER SURVEY

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In order to develop a monitoring system for evaluating forest ecosystems, a method of forest stand measurement using airborne laser survey was examined. The study area was a *Larix leptolepis* forest (100m×100m) in the Tomakomai Flux Research Site, Hokkaido, Japan (42°44'N, 141°31'E). Canopy height was approximately 15-16m and tree age was about 45 years old.

The laser survey data were taken in the year 1999, 2001 and 2003. A canopy DSM (Digital Surface Model) was constructed from first pulse of the laser survey data, and the DTM (Digital Terrain Model) was constructed from the last pulse of it. The DCHM (Digital Canopy Height Model) was made by the difference of the canopy DSM and DTM. The crowns of trees were extracted from the canopy DSM by the Watershed method. Tree height was measured by the difference of maximum altitude of laser point and DTM altitude within the extracted crown. The stem volume of trees was calculated by using the relationship between tree height and the stem volume. The tree height measured by the laser survey tends to be underestimated because of penetration in the foliage and missing tree tops. Therefore, tree heights are corrected by the relationship of the true height and measured height when the pulse density is thinned as a simulation. And, since the crowns of under-storey tree could not be detected in the laser survey, the MNY method (Hozumi, 1971) was used for the prediction of under-storey trees. The stand volume was calculated as the sum of stem volumes. The carbon weight of the stand was calculated by using the relationship between the wood volume and the wood dry-weight, and by multiplying the expansion factor, and the carbon content factor. NPP using laser survey was calculated as the sum of the annual carbon weight growth and the annual carbon weight of leaf fall. And, for the comparison, *NPP* by using micrometeorological method was calculated as

$$NPP = NEP + R_h - w_f \quad (1)$$

where *NEP* was the estimated NEP by the eddy covariance technique (Open- and closed-pass system) , R_h was the heterotrophic respiration and w_f was the carbon weight of forest floor plants.

The results that the growth of the forest stand height was 0.23~0.25cmyr^{-1}, and that the growth of the forest stand volume was 11m^{3}yr^{-1}, both were near to the data obtained by the complete enumeration. NPP calculated from the laser survey method and from the complete enumeration method were 298 gCm^{-2}yr^{-1} and 311 gCm^{-2}yr^{-1} , respectively. *NEP* by the Open- and closed-pass system was 566 gCm^{-2}yr^{-1} and 232 gCm^{-2}yr^{-1} (Hirata *et al.*, submitted) , R_h was 545 gCm^{-2}yr^{-1} (Liang *et al.*, 2004) and w_f was 355 gCm^{-2}yr^{-1}, then *NPP* became 756 and 422 gCm^{-2}yr^{-1}. This value was larger than the NPP by laser survey. This bias of NPP is thought that the formula (1) lacks the production of the rootlet. But, NPP calculated from the laser survey method and from the complete enumeration method were close value. Therefore, this method has a precision for the measurement of NPP.

P05

RELATIONSHIP BETWEEN THE REMOTE SENSED VEGETATION INDICES AND PHOTOSYNTHETIC LIGHT USE EFFICIENCY OF JAPANESE LARCH NEEDLES

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To clarify the utility of remote sensed vegetation index for evaluation of photosynthetic light use efficiency (LUE) of Japanese larch (*Larix kaempferi*), three types of spectral vegetation indices and daytime gas exchange rates of larch needles were investigated on different satellite overpass time.

In six clear days from early June to late October in 2003, the 4-band spectral reflectance (531, 570, 671 and 782 nm), net photosynthetic rate (*Pn*) and photosynthetically photon flux density (PPFD) were investigated at the canopy top of mature Japanese larch forest in Tomakomai, Japan (42° 44'N, 141° 31'E). The measurements were carried out two times per day, on near overpass time of Terra/MODIS (10:40 JST) and Aqua/MODIS (13:40 JST). Spectral reflectance of larch needles was measured using a portable spectral imager (MSI-4, Photron Co.), and the photochemical reflectance index (PRI)[1)], normalized vegetation index (NDVI)[2)] and difference of reciprocal reflectance ($1/R_{RED}$-$1/R_{NIR}$)[3)] were calculated from spectral reflectance as follows (R_λ denotes the reflectance at λ nm):

$$\mathrm{PRI} = (R_{531} - R_{570}) / (R_{531} + R_{570}) \quad (1)$$

$$\mathrm{NDVI} = (R_{782} - R_{671}) / (R_{782} + R_{671}) \quad (2)$$

$$1/R_{RED}\text{-}1/R_{NIR} = 1/R_{671} - 1/R_{782} \quad (3)$$

The *Pn* of the larch needles and the incident PPFD were determined using a portable photosynthesis system (Li-6400, Li-Cor, USA), and the LUE was calculated as *Pn* divided by the incident PPFD.

At the monitoring site, expansion of short-shoot needles was started from mid-May, and yellow color change of the needles was observed in late October. As well as phenology of needle growth, both *Pn* and LUE increased during summer, with peaks in August, and reduced in October. The *Pn* from June to July was significantly higher in the morning overpass time than that in afternoon overpass time due to higher irradiation in the morning period. However, no significant difference was found on the LUE between the overpass times.

The feature of seasonal variation differed among the analyzed vegetation indices. The NDVI and $1/R_{RED}$-$1/R_{NIR}$ stabilized from late June to September, and then reduced in October. On the other hand, the PRI increased from June to August, and reduced in October together with needle senescence. There was no significant effect of satellite overpass time on these vegetation indices.

Consequently, strong correlation was detected between the LUE and PRI of larch needles in both satellite overpass time ($r = 0.955$ in AM, $r = 0.954$ in PM). Although the significant correlations were found between the *Pn* and the analyzed vegetation indices, their correlations (coefficient correlation and regression line) were affected by observation time. Although further study is needed to develop the LUE estimation model for the large scale targets (ex. tree canopy and forest ecosystems), these results obtained in this study suggest that PRI is one of the useful indices for estimating the seasonal change in LUE of CO_2 flux in Japanese larch forest even by using snapshot data.

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P06

ANALYSES OF PHENOLOGY AT THE TAKAYAMA SITE USING A TIME SERIES OF FIXED VIEW CAMERA IMAGES

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A simple numerical method for analyzing phenology in a cool-temperate deciduous forest using seasonal variation of fixed view images was investigated. The images were taken in daytime everyday by a fixed camera, 'Gamo's Eye System', looking down the forest canopy located in the Takayama observation site, Japan. After digitizing each photo into RGB image data, normalized values (*r*, *g*, *b*) of the average intensities for each channel (red, green, blue) over the image were calculated. The seasonal variation of the normalized average intensities (Fig. 1) was compared with the observation of the images. As a result, it was found that discontinuities in the seasonal variation, i.e. days when maximum or minimum, change of increasing or decreasing rate of any of *r*, *g* or *b* appeared, were coherent with and utilizable to detect events such as snow melting, leaf opening, changing from new green leaves to mature leaves, autumn leaves, leaf shedding and so on. Also, discontinuities appeared in the time series of simultaneously observed parameters related to photosynthesis such as fPAR (Fraction of Absorbed Photosynthetic Active Radiation), PAI (Plant Area Index) were consistent with any of that appeared in the time series of *r*, *g* or *b*. These results suggest the possibility of application to a simple method to estimate photosynthetic parameters using fixed view images taken by handy imaging devices like digital still / video cameras or PC cameras.

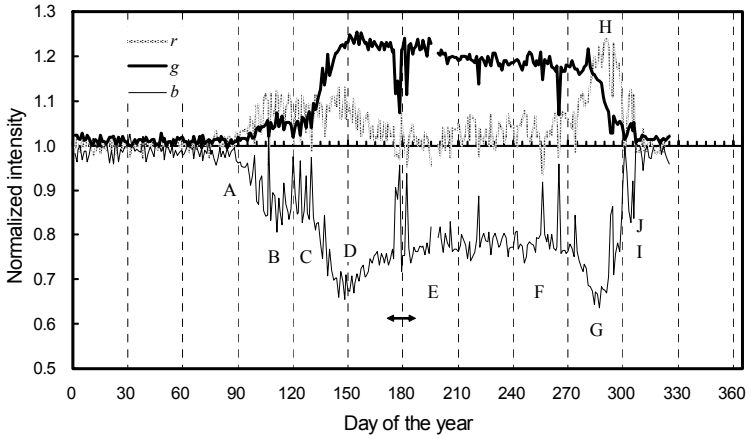

Fig.1 Seasonal variations of normalized average intensities r, g, b and y obtained from the fixed view images at Takayama site in 2002.

Letters plotted in the figure denote the days A: beginning of snow melting, B: end of snow melting, C: beginning of leaf opening, D: end of leaf opening, E: alteration from new green leaves to mature leaves, F: beginning of autumn leaves, G: peak of yellow leaves, H: peak of red leaves, I: end of leaf shedding, J: snowfall, respectively.

P07

RESEARCH PLAN AND STRATEGY OF THE FOREST OBSERVATION METHOD USING REMOTE SENSING IN THE FUJI-HOKUROKU SITE

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Remote sensing techniques are expected to play an important role in establishing the carbon sink assessment system for the Kyoto Protocol and the study of the carbon cycle on both the regional and global scale. So far, the technique for monitoring photosynthetic activity and phenological change of larch trees by passive remote sensing and the aboveground biomass measurement techniques by laser remote sensing were developed and verified at the Tomakomai Flux Research Site. We are going to develop remote sensing research of two themes like Tomakomai also at the new site in Fuji-hokuroku. The outline of two themes is described below.

1)Assessment of aboveground biomass

The airborne laser-profiler is a remote sensing technology that promises to increase the accuracy of wide-area biomass measurements. It can measure to an accuracy of about 15 cm in the vertical direction and 3cm in the horizontal direction. We are planning to observe 200ha around new Fuji flux research site with airborne laser-profiler, and high spatial resolution digital camera in this August or September. The laser-profiler provides us with the canopy height, the digital surface model (DSM), and the digital terrain model (DTM). The airborne digital camera acquires multispectral image with a resolution of 5cm from the altitude of 500m and is expected generating the three dimension model of 15cm resolution. By analyzing these data, the aboveground biomass of the larch forest is calculated and making it into the fiducial data of the year which began to measure CO_2 flux is expected.

2)Evaluation of forest ecosystems using hyper spectral reflectance

The hyper spectral reflectance over the forest is expected to obtain the information, related to the health condition, leaf biochemical contents ratio and photosynthetic activity. Hemispherical spectro radiometer system which covers the wavelength range from approximately 350nm to 1100nm with a spectral resolution of 7nm was developed in order to take the hyper-spectral reflectance of the forest canopy in the daytime automatically by cooperation with Phenological Eyes Network (PEN).

Two spectroscopes are mounted in the highest floor of the flux tower and observe hyper reflectance spectra of the canopy at intervals of 2 minutes. The goal of this research is comparing various vegetation indexes such as NDVI, PRI, WI with CO_2 flux using this data.

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P08

SPATIAL RESOLUTION EFFECT ON AREAL EVAPOTRANSPIRATION SIMULATION IN HAIBEI, TIBET PLATEAU, CHINA

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Quantification of areal evapotranspiration from remote sensing data requires the determination of surface energy balance components with support of field observations. Much attention should be given to spatial resolution sensitivity to the physics of surface heterogeneity. Using the Priestley–Taylor model, we generated evapotranspiration maps at several spatial resolutions for a heterogeneous area at Haibei, and validated the evapotranspiration maps with the flux tower data. The results suggested that the mean values for all evapotranspiration maps were quite similar but their standard deviations decreased with the coarsening of spatial resolution. When the resolution transcended about 480 m, the standard deviations drastically decreased, indicating a loss of spatial structure information of the original resolution evapotranspiration map. The absolute values of relative errors of the points for evapotranspiration map showed a fluctuant trend as spatial resolution of input parameter data layers coarsening, and the absolute value of relative errors reached minimum when pixel size of map matched up to measuring scale of eddy covariance system (was shown in Fig.1). Finally, based on the analyses of the semi-variogram of the orignal resolution evapotranspiration map and the shapes of spatial autocorrelation indices of Moran and Geary for evapotranspiration maps at different resolutions, the optimum resolution for the areal evapotranspiration simulation at this study area was determined.

Keywords: evapotranspiration; optimum resolution; spatial variation; eddy covariance; TM.

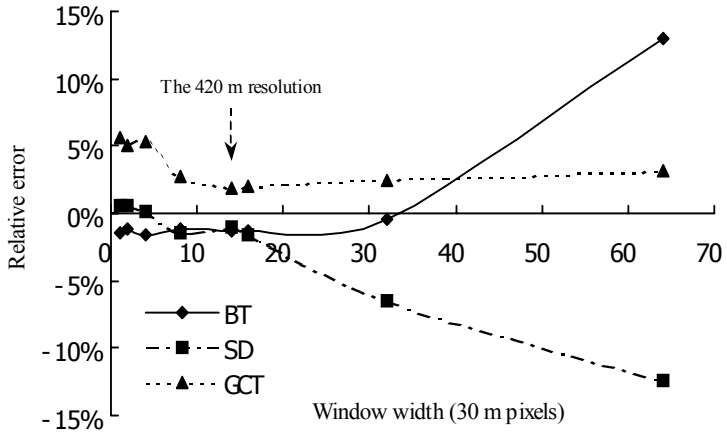

Fig.1 Different response of evapotranspiration simulation to the resolution coarsening at three ecosystems, BT: Meadow ecosystem, SD: Swamp ecosystem and GCT: Shrub ecosystem.

P09

RESPONSE CHARACTERISTICS OF PORTABLE CO_2 SENSORS

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Portable infrared CO_2 sensors are often used for soil CO_2 efflux measurements; however, such inexpensive small sensors are often relatively inaccurate and exhibit a slow response. The output signals are delayed both from diffusion processes in the sample cell and from internal averaging calculations for stable data output. Therefore, for accurate estimations of the CO_2 efflux, we need to know the actual increase in the CO_2 concentration in a chamber without these composite delays.

First, we conducted laboratory experiments to check the accuracy of each sensor, namely, GMD20, GMT222, GMM222, GMP343 (Vaisala), and Li820 (LiCor). The outputs of GMD20, GMT222, and GMM222 were monitored when the standard gas concentrations were 0, 353.3, 420.5, and 950 ppm. The errors ranged from 5 ppm to 140 ppm. After calibration, the maximum error reduced to 20 ppm or less. The error of GMP343 was below 1% after calibration. GMP343 had the highest accuracy among the Vaisala sensors. The error of Li820 was below 0.1%. Hence, the accuracy of Li820 was higher than that of GMP343.

Next, we conducted response experiments to parameterize composite delays under diffusion and flow-through conditions. Since Li820 has a quicker response in comparison with the other sensors, it was excluded from these experiments. The response time of a sensor when installed with a dust filter was longer than that without a dust filter. Furthermore, the response time of a sensor under the diffusion condition was longer than that under the flow-through condition. We developed a backward estimation method (BCDC: Backward calculation for delay compensation) for estimating the actual increase in the CO_2 concentration by using delayed sensor outputs. The actual CO_2 concentration is given by the following equation in BCDC:

$$C_t' = C_0 + (C_{t+b} + C_0)/(1 - \exp(-aT))$$

where a and b are the constants of each sensor; C_t', the expected CO_2 concentration in the chamber if the output of the sensor is not delayed; C_0, the initial CO_2 concentration in the chamber; C_{t+b}, the CO_2 concentration in the chamber at $t + b$ (s); and T, temperature (°C). The constants a and b of GMP343 diffusion type with a dust filter under diffusion condition were 0.0076 and 0 s, respectively, while those without the dust filter were 0.0133 and 0 s, respectively. Further, the constants a and b of GMP343 flow-through type under the flow-through condition were 0.2210 and 0s, respectively, and those of GMM222 probe type C with a dust filter were 0.0421 and 21 s, respectively.

We calculated the soil CO_2 efflux with the sensor outputs and modified CO_2 concentration by BCDC, using a nonlinear regression under diffusion model. The soil CO_2 effluxes calculated with the sensor outputs (F_{cal}) were always smaller than those calculated with the actual CO_2 concentration (F_{model}). The difference between F_{cal} and F_{model} decreased when the sampling interval was long. A long sampling interval may reduce errors; however, it is inefficient and sometimes has a negative effect because the closure of the chamber for a long period leads to changes in the chamber environment. This suggests that a short sampling interval leads to a large underestimate of the soil CO_2 efflux when the efflux is calculated with non-corrected data using the nonlinear regression. Thus, the correction of the sensor response with the backward estimation method provides an effective solution for archiving an accurate estimation of the soil CO_2 efflux using the sensors that are slow to respond.

P10

RELATIVE CONTRIBUTION OF ROOTS ON SOIL RESPIRATION IN A COOL-TEMPERATE DECIDUOUS FOREST IN KOREA

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The soil CO_2 efflux is a major source of CO_2 in terrestrial ecosystems and a key component of the carbon balance. The soil CO_2 efflux is resulted from the combinations of biological and physiological processes with high spatial and temporal variations. The objectives of this study were (1) to qualify the relationship between soil CO_2 efflux and environmental factors, such as soil temperature, and (2) to estimate the relative contribution of root respiration in soil CO_2 efflux. The study was carried out in a *Quercus mongolica* forest at Daegwallyeong Flux Measurement Site (DFMS), which is the typical cool-temperate deciduous forest in Korea. The measurements were carried out from August 2003 to August 2005. The soil CO_2 efflux and het erotrophic respiration were measured continuously with a multichannel automatic chamber system through the whole year.

The soil CO_2 efflux was increased exponentially with increase in soil temperature. We found a significant relationship between soil temperature and soil CO_2 efflux, root respiration and heterotrophic respiration, respectively. Annual soil CO_2 efflux and heterotrophic respiration in 2004 was 5.3 and 2.4 tC ha^{-1}, respectively. Annual root respiration in 2004 was estimated to be 2.9 tC ha^{-1} that accounted for about 55% of soil CO_2 efflux.

P11

SEASONAL CHANGE IN THE CONTRIBUTION OF ROOT RESPIRATION TO SOIL RESPIRATION IN A TEMPERATURE FOREST IN JAPAN

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INTRODUCTION

CO_2 flux from root, considered a part of soil respiration (*Rs*), plays an important role in the carbon cycle of forest. Hanson *et al*. (2000) concluded in their review that the contribution of root respiration (*Rr*) to *Rs* might converge at approximately 48.5% in the forest ecosystem. However, it is difficult to build the technique to separate accurately *Rr* from *Rs*. We had measured root respiration according to root thickness and it was shown that fine root had an important role in root respiration (Dannoura *et al*., 2003). In this study, we developed a new method for temporal *Rr* of fine root and evaluated the contribution of *Rr* to *Rs*.

SITE DESCRIPTION

Measurements were conducted at Yamashiro Experimental Forest (YEF) in Kyoto, which is a mixed forest of deciduous and evergreen broad-leaved trees including some conifers. The soil is immature and originated from granite. DBH (Diameter at breast high) of all trees (DBH > 1.0 cm) were measured in this research site in 1999 (Goto *et al.*, 2003).

METHODS

We developed an automatic chamber system for measuring CO_2 flux from fine root. It consisted of an IRGA (Li-820), a pump, and 5 chambers that were alternately operated. To measure only *Rr*, forest soil of A layer including organic matter was removed, and only living root was remained. Instead of removed soil, the space was stuffed with decomposed granite soil. Acrylic board was put between A and B layer to elude the influence of CO_2 flux from below B layer (mineral soil). At the same time, *Rs* and CO_2 flux from B layer were measured. We set up 3 chambers for *Rr*, 1 chamber for *Rs*, and the last one for CO_2 flux from B layer. At each chamber, CO_2 flux was measured at 35-min intervals, soil temperature and water content were measured continuously from April 2004 to May 2005.

RESULT AND DISCUSSION

From annual measurement of CO_2 flux using automatic chamber system, *Rr* of fine root responded exponentially to soil temperature. High soil moisture during and just after rainfall became limiting factor in *Rr*. *Rs* responded exponentially to soil temperature, too. There was positive relationship between soil water content and *Rs*. CO_2 flux from B layer did not make response to soil temperature and soil water content. From annual measurement, relationship between *Rr* and soil temperature did not change seasonally and *Rr* reached its peak at summer same as soil temperature. On the other hand, *Rs* showed clearly hysteresis to soil temperature. Therefor, yearly peak of *Rs* reached earlier than that of soil temperature. The ratio of *Rr* to *Rs* changed from about 20% to 70% through a year. The decomposition rate might be accelerated by high temperature and high soil water content in rainy season (June and July), so most litter was decomposed by summer. We suspected that the change in *Rr*/*Rs* ratio was caused by seasonal change of the amount of decomposed litter. These results suggested the importance of analysis of long-term measurement for discussion about the role of *Rr* in forest ecosystem.

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P12

CONTINUOUS MEASUREMENT OF CO_2 EVOLUTION FROM A JAPANESE CEDAR FOREST FLOOR USING A CHAMBER SYSTEM WITH AUTOMATIC OPEN AND CLOSING BASED ON AN OPEN-FLOW METHOD

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The carbon stock of Japanese cedar (*Cryptomeria japonica* D. Don) forests represents 24% (308 to 364 $\times 10^6$ Mg C) of the total Japan forests, with an area-weighted mean of 77 Mg C ha^{-1} (Fukuda *et al*., 2003; Fang *et al*., 2005). However, there are only a few studies concerning soil respiration in Japanese cedar forests (Simono *et al*., 1989; Ohashi *et al*., 1999; Shutou and Nakane 2004). The static CO_2 absorption method (Shutou and Nakane, 2004) and manual open-flow method (Simono *et al*., 1989; Ohashi *et al*., 1999) have been used to measure soil respiration for once a month on a just fine day. Some reports, however, demonstrated that the static CO_2 absorption method might be inadequate for field measurements (Edwards and Sollins, 1973; Nakadai *et al*., 1993). It has been also confirmed that CO_2 concentration in the chamber (Hanson *et al*., 1993; Nakadai *et al*., 1993) and rainfall (Lee *et al*., 2002) significantly affect soil respiration rate. Moreover, the measurement at night or on rainy days is strongly limited with these methods because human intervention is required. Thus, it is important to consider both short-term and long-term measurements that account for changes in various environmental factors. To accomplish these subjects, we established a chamber system with automatic open and closing for measuring continuous soil respiration based on an open-flow method (AOCC) described in the previous study (Suh *et al*., *in press*). In the present study, our object is to examine seasonal changes in soil respiration of a Japanese cedar forest using the new chamber system. We also evaluated the relationship between soil respiration rates and environmental factors, such as soil temperature and soil moisture.

The study area was a Japanese cedar plantation located in Takayama city, central Japan (36º 08' N, 137º 22' E). The plantation was approximately 50 years old. This region refer to a cool temperate zone, Asia monsoon climate. The annual mean of air temperature and precipitation for 44 years (1961–2004) were 11ºC and 1745 mm, respectively (data from Japan Meteorological Agency). The ecological-process research plot was established on the middle of a slope (30 m×50 m) in November 2004. The altitude of plot ranged from 800 to 850 m. The slope inclination ranged from 10º to 20º. The slope direction is south-east. The site had 1153 trees ha^{-1} with ca. 20-25 m in height. The study site was rice terrace before conducted Japanese cedar plantation.

The AOCC system is composed of three main parts: a chamber system, plus pumping and timer systems. Each chamber system consisted of three parts: chamber, cell, and soil collar. The chamber systems have an elongated octagonal shape (20×30×8 cm, L×W×H) to avoid the stagnation of circulation in any zones. A top frame encloses the upper part of the chamber and supports a fixed, 12V DC motor and two limit switches. An acrylic lid (0.5 cm thick) is supported on both short sides of the top frame. Further descriptions on the system are given by Suh *et al*. (*in press*). We installed the six chambers at locations with east-facing slope (n = 3, subplot: 15 m×10 m) and north-facing slope (n = 3, subplot: 10 m×10 m) on 25 April 2005. To establish each chamber, we inserted the collars at the depth of 6 to 8 cm below the top of the litter layer, cutting through the surface litter and roots. We operated the AOCC over a period of about 4 months, from May to August in 2005. Each chamber measurements during 30-min and then one measurement cycle of 3 hours were repeated. Analysis data were used when the CO_2 concentration at the air outlet reached a steady state. The raw CO_2 signals from the IRGAs (LI-820) were sampled every 10s and averaged every 1-min. We measured air temperature at the height of 30 cm near the chambers and soil temperatures at depth of 5 cm in the chambers. Continuous measurements of soil temperature and water content by TDR were carried out near the chambers at a soil depth of 5 and 10 cm below the top of the litter layer at 30-min intervals over the entire study period.

In this study site, no marked diurnal trends in the soil respiration rates were observed on days without rainfall. In contrast, significant changes in soil respiration rates were detected on days with rainfall events. The exponential relationship between soil temperature and soil respiration rates accounted for approximately 50 % of the soil respiration rate variability. Also, soil respiration rates in east-facing slope tended to be higher than those in north-facing slope. Our results indicated that soil respiration rates are strongly related to not only soil temperature but also soil water content and/or precipitations.

P13

LONG-TERM MEASUREMENTS OF SOIL RESPIRATION IN AN AGRO FOREST ECOSYSTEM IN KOREA

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The soil CO_2 efflux is a major source of CO_2 in agroforest ecosystems and a key component of the carbon balance. The soil CO_2 efflux is resulted from the combinations of biological and physiological processes with high spatial and temporal variations. The objective of this study was to determine the relationships between soil CO_2 efflux and environmental factors, such as soil temperature, soil moisture, air temperature and depth of soil A_1 layer in spatial variation. This study was carried out at the flux measurement site in an apple agroforest ecosystem (AFMS), in Euiseong, Korea. The measurements were carried out from August 2004 to August 2005.

The soil CO_2 efflux was measured with a multichannel automatic chamber system through the whole year. We found that the soil CO_2 efflux was increased exponentially with increase in soil temperature. Soil CO_2 efflux Q_{10}, derived from all measurements, was 3.5 during the measurement period.

P14

SOIL CO_2 EFFLUX IN A TEMPERATE FOREST ECOSYSTEM UNDER MONSOON CLIMATE IN NOTRHEAST ASIA

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Soil CO_2 efflux is the primary component (≈70%) of ecosystem respiration in forests. Quantitative and qualitative understanding of soil carbon emission is therefore critical for identifying carbon sink/source strength of forest ecosystems in the context of climate change protocols. Although soil temperature is the major controlling factor in the annual soil carbon emission, a realistic long-term estimation under monsoon climate must take the effect of precipitation into account. The objectives are to estimate annual carbon emission from deciduous broad-leaved forest floors and to investigate the influence of monsoon climate on interannual variability of soil CO_2 efflux. The annual soil carbon emission from site for three years averaged about 871 g C m^{-2} with an annual variability of the order of 10%. Such variation, however, could not be explained by the annual variations of soil temperature, suggesting the potential influence of other controlling factors such as soil water content. However, no clear relationship was apparent between soil CO_2 efflux and soil water content due to the confounding effect of both positive and negative correlations. The variability of soil carbon emission was then related to changes in magnitude, duration, and frequency of precipitation particularly during *Changma*, the rainy spell in summer. Contrary to our expectation with moderate and persistent rainfalls, an excess of soil water rather restrained CO_2 efflux. These results clearly indicate that the changes in intensity and frequency of precipitation can significantly alter the carbon sink/source strength of forest ecosystems in monsoon. This study is supported by “The Eco-Technopia 21 Project” from the Ministry of Environment, Korea.

P15

INFLUENCE OF SOIL TEMPERATURE AND MOISTURE ON SPATIAL VARIATION OF CO_2 EFFLUX ON FOREST FLOOR IN SMALL CATCHMENT -IN CASE OF YAMASHIRO EXPERIMENTAL FOREST, MAY 2004-APRIL 2005-

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1. Site Description and Methodology

The CO_2 efflux on the forest floor (F_c: mg CO_2 m^{-2} s^{-1}) was observed at the plots settled on a ridge and in a valley in the Yamashiro Experimental Forest, located at 34° 47' N, 135° 50' E, in southern Kyoto Prefecture, Japan. The distance between the two plots was 70 m horizontally and 35 m vertically. The region is covered by a deciduous broad-leaved secondary forest dominated by oak. In 1999, the total basal area and aboveground biomass of stems with a diameter at breast height (DBH) greater than 3 cm were 20.7 m^2 ha^{-1} and 105.05 t ha^{-1}, respectively. The same authors recorded the average litterfall, mean temperature, warmth index, and annual precipitation for 1999-2002 as 5.16 t ha^{-1} $year^{-1}$, 5.5°C, 125.6°C $month^{-1}$, and 1449.1 mm, respectively. The forest soil originates from granite, and has an immature structure. The forest floor at the experimental forest was consistent with this regolith, and the organic carbon content was less than 2.75%.

The CO_2 efflux was measured using an automated chamber with an enclosed infra-red gas analyzer (IRGA; Tamai *et al*., 2005a), which is classified as a closed static method. Soil temperature (T_s: ºC) and soil moisture (θ: m^3 m^{-3}) at 5-cm depth were also measured near the automated chamber. The data for May 2004 to April 2005 was analyzed in this study.

2. Results and Discussion

The average rate and standard deviation of "F_{cv} - F_{cr}" was calculated for every 5-6 days, where F_{cv} and F_{cr} are the CO_2 efflux in the valley and on the ridge, respectively. A clear difference between F_{cv} and F_{cr} was defined as the range of standard deviation that did not include "F_{cv} - F_{cr} = 0 mg CO_2 m^{-2} s^{-1}". F_{cv} was up to 0.04 mg CO_2 m^{-2} s^{-1} larger than F_{cr} from July to September 2004, while F_{cr} was slightly larger than F_{cv} (less than 0.01 mg CO_2 m^{-2} s^{-1}) from November 2004 to March 2005.

Tamai *et al*. (2005b) reported Eq. (1) based on observations at five plots in Yamashiro Experimental Forest, including the two plots observed in this study.

$$F_c = 0.0566 \exp(0.0717 T_s) \frac{\theta}{\theta + 0.1089} \qquad (1)$$

"F_{Ts} - F_{rcal}" and "F_{θ} - F_{rcal}" were calculated when F_{cr} and F_{cv} clearly differed. F_{Ts}, T_{θ} and F_{rcal} were calculated by substituting the respective values of T_s in the valley and θ at the ridge, T_s at the ridge and θ in the valley, and T_s and θ at the ridge, respectively into Eq. (1). "F_{Ts} - F_{rcal}" and "F_{θ} - F_{rcal}" are thought to indicate the effects of soil temperature and soil moisture on "F_{cv} - F_{cr}", respectively.

The calculated results show that "F_{Ts} - F_{rcal}" and "F_{θ} - F_{rcal}" had marked effects on "F_{cv} - F_{cr}" from November 2004 to March 2005 and from July to September 2004, respectively. This means that the cause of the difference between F_{cv} and F_{cr} was the spatial difference in soil temperature and soil moisture during the respective periods.

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P16

EXPORT OF DISSOLVED ORGANIC CARBON FROM KOREAN NATURAL FOREST CATCHMENT DURING STORM EVENTS

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The carbon exchange between terrestrial ecosystems and the atmosphere has been quantified in various biomes and climate regions. The movement of water also exports dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), and particulate organic carbon (POC) from the soil. These materials contribute significantly to the carbon cycle, because the transport of soil-derived organic matter by rivers and its subsequent burial in coastal sea sediments is an important sink for carbon. The presented data have shown that these carbon fluxes through rivers are an important component in the global carbon cycle. Therefore, we intensively measured DOC, anions and cations in soil water, groundwater and streamwater during storm events, especially in Monsoon.

This study was conducted in the Gwangneung deciduous forest catchment (22ha), located in the Gyeonggi-do near Seoul metropolitan (elevation: 280 ~ 470m; 37° 44' N, 127° 09' E). The mean annual air temperature was 11.5℃, and average annual precipitation was 1436 mm between 1970 and 2002. Much of precipitation concentrates in summer Monsoon. The Gwangneung deciduous forest catchment was prohibited forest management such as thinning, and preserved naturally. The Gwangneung deciduous forest catchment is covered with weathered gneiss over the whole area. Hillsides with slopes 10~20° account for 80% of the total area, while maximum slope was 51°. The soil texture is sandy loam.

We found high concentration of DOC in shallow soil water during pre-events, and it ranged from 20 to 80 $mg \cdot L^{-1}$. However, DOC concentrations in groundwater decreased with increasing well depth. It seems to be that decreasing of DOC concentrations with well depth due to adsorption and decomposition process in soil layer. It showed decreasing of DOC concentration in shallow soil water during storm events. Although DOC concentrations in streamwater were showed below 1 $mg \cdot L^{-1}$ during base flow, they were drastically increased to 6 $mg \cdot L^{-1}$ with increasing runoff discharge during storm events. The maximum carbon efflux through DOC was investigated 0.6 $kg \cdot 10min.^{-1}$ with runoff discharge 1.05 $mm \cdot 10min.^{-1}$. Furthermore, DOC concentration in spring water increased about 10 times after storm events. These results suggest that DOC discharge through lateral flow significantly contributes carbon efflux during storm events. Our result also suggests that Monsoon is important component to evaluate the carbon flux in Korean natural forest.

P17

Fluxes of CH_4 and N_2O from soil under tropical seasonal rain forest in Xishuangbanna, Yunnan, SW China*

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Abstract: CH_4 and N_2O fluxes from soil under tropical seasonal rain forest in Xishuangbanna, SW China, were measured for 1 year by using the closed static chamber technique and gas chromatography method. Three treatments were set in the studied field: (A) litter free, (B) with litter, (C) with litter and seedling. The results show that the soil in our study was a sink of atmospheric CH_4 and a source of atmospheric N_2O. The observed mean CH_4 fluxes from treatments A, B, and C were –57.5 ± 6.9, –35.9 ± 2.8, –31.6 ± 2.8 μg CH_4–C m^{-2} h^{-1} (Mean ± SE), respectively, and calculated annual fluxes in 2003 were –5.19, –3.15, and –1.44 kg C ha^{-1}, respectively. The observed mean N_2O fluxes from treatments A, B, and C were 30.9 ± 3.1, 28.2 ± 3.5, 51.9 ± 4.1 μg N_2O–N m^{-2} h^{-1}, respectively, and calculated annual fluxes in 2003 were 2.92, 2.64, and 4.36 kg N ha^{-1}, respectively. Seasonal variations in CH_4 flux were significant in all three treatments and seasonal variations in N_2O fluxes only existed in treatment C. Litter decreased CH_4 uptake, which were mainly observed in the wet season. Seedlings increased N_2O emission, which occurred in the dry season. A strong positive relationship existed between CH_4 fluxes and soil moisture for all three treatments, and between CH_4 fluxes and soil temperature for treatment A and treatment C. N_2O fluxes correlated with soil temperature for all three treatments.

Key words: Greenhouse gases; Seasonal variability; Tropical seasonal rain forest; Xishuangbanna

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P18

HETEROGENEOUS NATURE OF SOIL ORGANIC MATTER AS INDICATED BY RADIOCARBON SIGNATURES

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Recent debate over the importance of soil organic matter (SOM) in the global carbon budget has emphasized a lack of fundamental knowledge of soil carbon dynamics and a difficulty in predicting the magnitude and timing of the response of soil carbon reservoir to changes in climate. This is mainly due to the lack of understanding of heterogeneous nature of SOM. In this study, SOM is separated by a chemical fractionation method into organic matter fractions with different chemical stabilities, and then radiocarbon (^{14}C) abundances of the fractions are determined by an accelerator mass spectrometry (AMS) to characterize the heterogeneous nature of SOM.

Soil sampling was made in a temperate-zone forest in Aichi prefecture, Japan. The mineral soil layer was covered with 4 cm forest litter layer, which was composed of a leaf litter layer of 3 cm thickness and a well-decomposed leaf debris layer of 1 cm thickness. Samples of mineral soil were collected at 1 cm, 2 cm and 5 cm intervals for 0-10 cm, 10-20 cm and 20-40 cm depth layers, respectively. The soil samples were dried to constant weight, sieved with a 106 μm mesh in distilled water and re-dried. The soil was then fractionated chemically with a method described in Fig.1. The bulk soil was hydrolyzed with 1.2 N HCl at 130 ^{o}C repeatedly. After the hydrolysis, organic matter left in the residual solid was defined as "non-hydrolysable fraction". The residual solid was further treated repeatedly with 1.2 N NaOH at 130 ^{o}C, and hydrolyzed several times with 1.2 N HCl at 130 ^{o}C. The organic matter remaining in the solid obtained here was defined as "humin fraction". Radiocarbon abundances in the fractions were measured with AMS at Tono Geoscience Center, Japan Nuclear Cycle Development Institute. In this study, ^{14}C data are presented as $\Delta^{14}C$, the permil (‰) deviation from $^{14}C/^{12}C$ ratio of a standard selected so that $\Delta^{14}C$ is zero for atmospheric CO_2 in 1950.

Radiocarbon signatures of SOM fractions are given in Fig.2. The highest $\Delta^{14}C$ values were observed in the bottom of forest litter layer in bulk and non-hydrolysable fractions, indicating the considerable amount of carbon fixed over the past four decades is still preserved in this layer where the microbial decomposition of SOM is highly active. The depth profiles also suggest leaching of a part of the ^{14}C-enriched SOM from surface to the deeper layer (8 cm). The ^{14}C signatures of the non-hydrolysable fraction were rather lower than those of the bulk fraction. This means that carbon in hydrolysable fraction have higher $\Delta^{14}C$ values, implying that this fraction (approximately 70% of total carbon) become the most important pool for carbon exchange on annual to decadal timescales. On the other hand, significant radioactive decay was observed for carbon in humin fraction of mineral soil layers, demonstrating that the chemically recalcitrant SOM, accounting for 4-10% of total carbon in this soil, plays a role as a long-term sink in the carbon cycle.

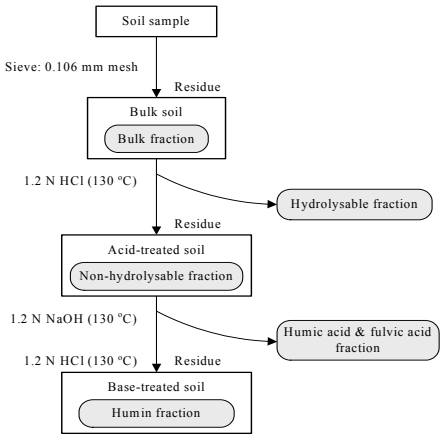

Fig.1. A chemical fractionation method.

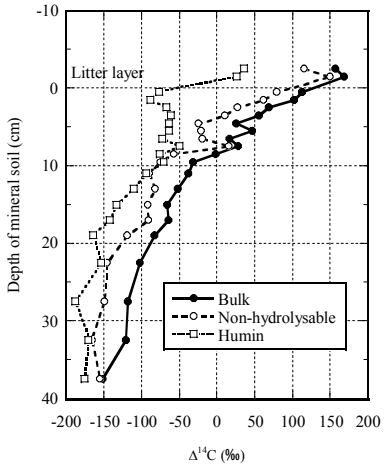

Fig.2. Radiocarbon signatures in SOM fractions.

P19

IS CARBON STABLE ISOTOPE RATIO OF HETEROTROPHIC RESPIRATION INVARIANT? ~WHAT WE LEARNED FROM OBSERVATIONAL FACTS~

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To investigate potential variability in $^{13}C/^{12}C$ ratio of heterotrophic respiration, we measured $^{13}C/^{12}C$ ratio of CO_2 respired from soil at plots with and without "root-exclusion" in a deciduous needle leaf forest in Japan for 3 years. High-precision measurement coupled with a sampling system optimized for soil respiration made it possible to detect spatiotemporal variability intrinsic to heterotrophic respiration. Even in the absence of root respiration, the $^{13}C/^{12}C$ ratio of soil-respired CO_2 had significant seasonal variation with range greater than previous model estimate. The $^{13}C/^{12}C$ ratio of soil-respired CO_2 at the root-excluded plot generally showed minimum in early summer but its temperature relationship was not monotonous like that in the CO_2 efflux. Those observational facts would have implications for future validation of model predictions. Our results also showed that the $^{13}C/^{12}C$ ratio of soil-respired CO_2 had significant short-term variability related to temperature change and large spatial variation even without influence of root-respiration. Under the limitations of chamber-based measurement, the spatial variations would give sampling bias that made it difficult to estimate flux-weighted mean value of the d13C in canopy-or-larger spatial scales. While much remains to be learned about the natural variations in the $^{13}C/^{12}C$ ratio of soil-respired CO_2, the variations in the $^{13}C/^{12}C$ ratio of soil-respired CO_2 observed in this study likely captured some characteristics intrinsic to heterotrophic respiration.

P20

LEAF ECOPHYSIOLOGICAL PROCESSES FOR THE PHOTOSYNTHETIC PRODUCTIVITY IN A COOL-TEMPERATE DECIDUOUS FOREST ECOSYSTEM AT TAKAYAMA SITE.

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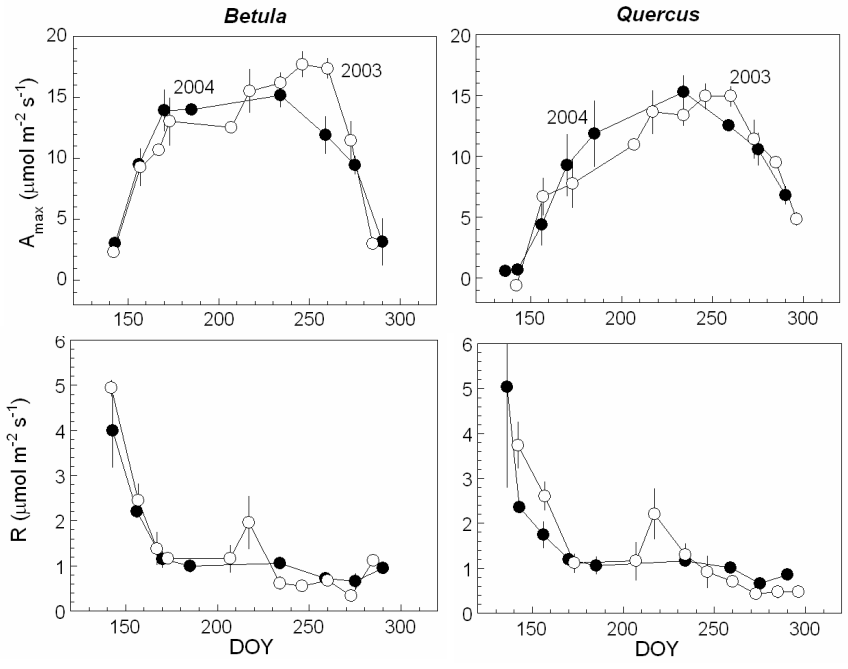
Plant ecophysiological properties including photosynthetic responses to environmental conditions, canopy geometrical consequences with photosynthetic carbon gain and their seasonality have considerable responsibility to the forest ecosystem carbon fixation. This paper overviews these traits for canopy tree species in a cool–temperate deciduous broadleaved forest of Takayama AsiaFlux site located at central Japan.

Two–year measurements of leaf CO_2 gas exchange characteristics for full growing season on canopy tree species, *Betula ermanii* and *Quercus crispula*, revealed that their photosynthetic capacities increase with leaf expansion from late spring (mid May) to early summer (June) in 2004 or mid summer (August) in 2003 and decrease in autumn (October). In contrast, seasonal change of dark respiration was similar between the two years in both tree species; the maximum was observed at the start of leaf expansion and decreased by June when the leaf area matured. Leaf and shoot (branch) level photosynthetic and geometrical consequences to canopy carbon gain were examined with a 3–D structural–functional model, Y–plant. Simulations with shoots at the canopy top of *Betula* and *Quercus* revealed that the steeper leaf angle and higher stomatal conductance of *Betula* contribute to maintaining high photosynthetic activity by reducing high light stresses such as heat load and photoinhibition. Comparison of sunlit (canopy top) and shaded (inner canopy) shoots of *Quercus* revealed that the leaf display with small self–shading of shade shoots is effective in receiving light incidence in the light–limited environment, but prolonged sunfleck limits photosynthesis of the shade leaves by increasing temperature and stomatal closure.

These ecophysiological considerations of plant photosynthesis and structure would provide us deeper insight into the mechanistic understanding of the forest ecosystem carbon gain in changing environments.



Seasonal changes of photosynthetic capacity (A_{max}) and dark respiration (R) of the leaves of *Betula* and *Quercus* in 2003 and 2004. Symbols and error bars reprent mean ± SD of 3 – 7 leaves.

P21

SEASONAL VARIATION IN THE NOCTURNAL WOODY-TISSUE RESPIRATION OF A MIXED BROAD LEAVED FOREST

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1. INTRODUCTION

To understand how deciduous and evergreen trees control nocturnal CO_2 flux in Yamashiro Experimental Forest (YEF), we measured the seasonal variation in the nocturnal woody-tissue respiration of the deciduous and evergreen trees using a static automated chamber method. In this study, we estimated the ratio of growth respiration to total annual nocturnal respiration.

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 stem respiration using static, automated stem chambers in the YEF. The chamber automatically measured nocturnal stem 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 the stem chambers to stems of *Q. serrata* and *I. pedunculosa* (DBH, 20.7 and 17.9 cm, respectively) at breast height. The air temperature within the stem chamber was measured with a copper-constantan thermocouple. Nocturnal respiration of woody tissue per unit surface area of *I. pedunculosa* and *Q. serrata* (F_{wI} and F_{wQ}, respectively) were calculated from the difference in CO_2 concentrations between 30 and 210 sec (3 min) in chambers. We collected data continuously from 1 May to 31 December 2003. We measured the relationship between DBH and the surface area of woody tissue on the sample trees. We defined surface areas of trees from the sum of twig surface areas, and measured twig surface areas using slide gauges directly. We used F_{wE} and F_{wD}, respectively, to represent the whole-tree respiration of woody tissue for evergreen and deciduous trees.

3. RESULTS AND DISCUSSION

The relationship between DBH(cm) and stand-level surface area of woody tissue (SA, cm^2) was expressed by the following allometric equation ($SA = 247\ DBH^{2.24}$, $R^2 = 0.949$). We confirmed the linearity of the relationship between surface area and the respiration rate of woody tissue using destructive stem samples. The ambient air temperature was strongly correlated with respiration by woody tissue, except during the growing season, when there was relatively high growth respiration. The growing season for stems of *Q. serrata* was 1 month longer than that for *I. pedunculosa*. The proportions of F_{wE}, and F_{wD} to nocturnal whole-tree aboveground respiration (F_{tree}) were estimated to be 8 and 16%, respectively. The rate of growth component of F_{wE}, and F_{wD} in F_{tree} were estimated as 1 and 2%, respectively. These results suggest the importance of exact estimation of woody tissue respiration in similar forests.

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P22

ESTIMATING THE CO_2 FLUX FROM COARSE WOODY DEBRIS IN A TEMPERATE DECIDUOUS BROAD-LEAVED FOREST IN JAPAN

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INTRODUCTION

CO_2 sequestration in forest ecosystems plays a key role in the global carbon cycle. Forest uptake CO_2 via photosynthesis and release CO_2 via autotrophic and heterotrophic respiration (R_a and R_h respectively). NEP is the small difference between the two large fluxes, so an understanding the biological and physical characteristics of all of the processes in a forest is necessary to estimate how the carbon cycle will respond to environmental change. R_a can be considered in a quantification of NPP, while R_h has to be treated as an independent compartment, because R_h relies on the amount of dead plant tissues. Coarse woody debris (CWD) releases CO_2 that affects the carbon cycle of a forest for 10 to 100 years after death, because it decomposes slowly. However, the CO_2 flux from CWD (R_{CWD}) is hardly included in measurements of soil respiration, and few studies have treated CWD as a CO_2 source. Therefore, this study focused on CWD and estimated the annual R_{CWD} in a forest to evaluate the contribution to R_h and NEP.

SITE & METHODS

R_{CWD} was measured in the Yamashiro Experimental Forest (YEF), in Kyoto, Japan. The forest is a secondary deciduous broad-leaved forest dominated by *Qercus serrata* and *Irex pedunculosa*. The stand density (DBH≥3cm) is 3,209 ha^{-1}, the mean crown height is about 12m, and the living biomass is 44.54tC·ha^{-1}. The soil is generally thin, immature, and sandy. To examine the temporal changes in R_{CWD} due to the environmental factors, automated chamber were installed on two CWD samples and measured R_{CWD} 72 times a day from 2002 and 2003. For modeling of R_{CWD} to environmental factors and CWD characteristics, R_{CWD} of 192 CWD samples, which were cut from snags and logs in the forest, were measured. CWD census in 2003 and CWD input census from 1999 to 2994 were made from the field surveys. For the evaluation of CWD carbon cycle, the annual R_{CWD} was scaled to the ecosystem after considering environmental factors associated with the position (snag or log) of CWD and CWD characteristics.

RESULTS

Long-term continuous measurements of the R_{CWD} of two samples showed daily and seasonal patterns with changes in T. Precipitation events caused notable changes in the R_{CWD} of both samples. Manual measurements of R_{CWD} of 192 samples showed that R_{CWD} was correlated with temperature (T), water content(θ), wood density(ρ), and diameter (D) of CWD; ($R_{CWD} = 78.5\exp(0.0494T)(\theta+0.0591)(0.871-\theta)0.581\ D^{-0.682}\ \rho^{-0.790}$) and the function explained 53% of the variance in R_{CWD}. Measurements of environmental factors of snags and logs showed that the θ of snags was 20% of that of logs. A field survey conducted in 2003 estimated the CWD mass as 9.30 tC·ha^{-1}. Seventy percent of the CWD had been created before 1999. Snags constituted 60% of the total CWD mass. The annual R_{CWD} estimated in 2003 in YEF was 0.50tC·ha^{-1}·yr^{-1}, amounting to 13-19% of R_h. The mean annual CWD input from 2000 to 2004 was 0.61tC·ha^{-1}·y^{-1}, and 60% of this occurred as snags. Snags fell to the ground during sporadic events, such as typhoons. The forest sequestered 0.11tC·ha^{-1}·y^{-1} as CWD, which was 7% of the NEP (1.56tC·ha^{-1}·y^{-1}) estimated from tower and biometric measurements.

DISCUSSION

R_{CWD} was controlled by both environmental factors and CWD characteristics. In YEF, snags constituted 60% of the total CWD mass. The water content of snags was markedly lower than that of logs. Therefore, the difference in water content due to CWD position (snag or log) affects the annual R_{CWD} in YEF. Most CWD initially occurs as snags, which then fall to the ground during sporadic events and subsequently decompose more rapidly. Therefore, the transformation of snags into logs is an important event in the CWD carbon cycle. Since CWD forms accidentally during disturbances and decomposes more slowly, it is difficult to assume that CWD input and decomposition are balanced. Therefore, in order to quantify the carbon cycle in forest, it may be important to consider the CWD balance in a forest, especially when CWD is abundant in the forest or the forest conditions have recently changed.

P23

BIOMETRIC BASED ESTIMATES OF NET ECOSYSTEM PRODUCTION IN A COOL-TEMPERATE DECIDUOUS FOREST BENEATH A FLUX TOWER

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The eddy-covariance based estimates of NEE clearly demonstrated that temperate forests have significant contribution to the global uptake of CO_2 (Wofsy et al. 1993). An alternative approach to measuring carbon sequestration is biometric based estimates of net ecosystem production (NEP), which is described as the balance between net primary production (NPP) and heterotrophic respiration (Rh). Inter-comparison of NEP and NEE in a flux site is important not only to cross-validation of both independent methods but also to qualify the contribution of various biological processes to NEE. We conducted that biometric based NEP in a temperate deciduous broad-leaved forest beneath a flux tower. Our objectives are 1) to help accurate estimates of forest carbon storage, and 2) to show how and where the forest is storing C.

The study site is located in Takayama Forest Research Station, River Basin Research Center, Gifu University. The site is a part of Asia Flux Network that is presently measuring CO_2 and energy exchange between forest canopy and the atmosphere from 1993 (Yamamoto et al. 1999). A permanent plot of 1 ha was set on a west-facing slope. The flux tower is included in the plot. Forest compartment model was applied to construct for stand-level mass balance of carbon budget. Biometric NEP is conceptually equivalent to the sum of the change in carbon pools ($\triangle$C), i.e., plant biomass (B), coarse woody debris (CWD), and soil organic carbon (SOC). Annual $\triangle$C in each carbon pool was based on process-level flux measurements. Annual growth of tree dbh was measured in each winter to estimate annual biomass increment ($\triangle$B) from 1999. Annual detritus production was estimated from 14 litter traps (1 m^2 area). Diurnal and seasonal change in soil surface CO_2 efflux were measured continuously for 24-48 h once or twice a month with the open-flow (OF) IRGA method using four chambers beneath the flux tower from 1999. Heterotrophic respiration was separated from root respiration based on comparisons of CO_2 efflux between untrenched and trenched areas in the permanent quadrat (Lee et al. 2003).

The mean annual tree growth of above-ground and large roots amounted to 1.3±0.47 t C ha^{-1}. However, $\triangle$B in the site was rather small (0.3 t C ha^{-1}) because of annual tree mortality amounted to 1.0 t C ha^{-1}. Annual coarse litter production (branches) varied year-to-year ranged from 0.19 to 0.70 t C ha^{-1} compared to less variable fine litter (foliage) production (1.8±0.14 t C ha^{-1}). The soil surface CO_2 efflux was determined as the average across a 5-year record (8.4±0.52 t C ha^{-1}). The contribution of the root respiration of the total soil respiration was 45.3%, thus, Rh was 3.9±0.24 t C ha^{-1} with topographical correction. The mean total C uptake ($\triangle$C) of the Takayama site is 2.6 t C ha^{-1} yr^{-1} during 1999 to 2003, which agree well with eddy-covariance based NEE (Saigusa et al. 2005, 237±92 g C m^{-2} yr^{-1} from 1994 to 2002) within 10% mean value. However, validation of $\triangle$SOC is still limited by an insufficient data of the below-ground detritus production (fine root of trees and rhizomes of dwarf bamboo). These limitations make it difficult to estimates accurate $\triangle$C by process-level flux measurements.

P24

INTER-ANNUAL VARIABILITY OF NET PRIMARY PRODUCTION AND SOIL CO_2 EFFLUX IN A COOL TEMPERATE RED PINE FOREST AT NORTHERN FOOT OF MT. FUJI

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The carbon flux between the terrestrial and the atmosphere, which has been decided by balance that CO_2 emission from the land use change and the substantial CO_2 absorption by plant was clarified by the third report of IPCC in 2001. It is important to know the carbon budget of the terrestrial ecosystem because CO_2 has largest contribution to global warming. Therefore the tower flux observation in forest ecosystems was spread rapidly in 1990's to comprehend the substantial CO_2 absorption in the terrestrial ecosystem. Ecological measurement of carbon budget beneath the flux tower is needed for accurate estimate of carbon budget. In this study, we aimed to consider that inter-annual variability of net primary production and soil CO_2 efflux and how dose they contribute to net ecosystem production in a forest ecosystem, and to show where and how the forest is storing carbon.

The study site is located in northern foot of Mt. Fuji (35°27′N, 138° 4 6′E, 1030m a.s.l.). Secondary forest of red pine (*Pinus densiflora*) was established on the Kenmarubi lava flow, which was formed in 937. This site is a part of the Asia Flux Network that is presently measuring CO_2 flux from 1999.

The permanent quadrat of 0.64 ha (80m×80m) was set on 2000 near the flux tower. NPP was estimated by the harvest method as expressed by the sum of ⊿B (annual biomass increment) + L (annual litter production). Annual biomass increment was estimated by measuring the dbh of all living stems greater than 5cm in December after growing season from 2000. 20 point of litter traps ($1m^2$) and 9 point of big branches traps ($100m^2$) were used to estimate the litter production. These samples were collected at monthly intervals from 2000 to 2004, and dried and weighed. Soil CO_2 efflux was measured by three methods (2000-2002: Automated closed chamber method, 2003: Closed chamber method, 2004: LI-6200).

Annual tree growth was fluctuated 2.18 ton C ha^{-1} to 2.91 ton C ha^{-1} in five years. Annual biomass increment was fluctuated 1.81 ton C ha^{-1} to 2.50 ton C ha^{-1}, and annual tree mortality was 0.35 ton C ha^{-1} to 0.76 ton C ha^{-1} in four years. Mean annual litter production (including big branches) was 3.50 ton C ha^{-1} in five years. NPP was fluctuated 5.68 ton C ha^{-1} to 6.41 ton C ha^{-1} in five years, soil CO_2 efflux was almost constant excluding 2004 (3.22 ton C ha^{-1} to 4.08 ton C ha^{-1}). We assumed that heterotrophic respiration is 83% of soil respiration (Sakata personal communication). Therefore, NEP that is estimated by subtracting heterotrophic respiration from NPP was fluctuated 2.84 ton C ha^{-1} to 3.73 ton C ha^{-1}. Moreover, the mean annual carbon storage in the forest ecosystem in five years was 2.20 ton C ha^{-1} in plant biomass, 0.33 ton C ha^{-1} in soil organic carbon, 0.71 ton C ha^{-1} in coarse woody debris.

P25

CARBON BALANCE OF LARCH FOREST ECOSYSTEMS

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Forests worldwide contain about 45% of the global stock of carbon, the large part of which is found in forest soils. They impact upon the natural cycle of carbon, nitrogen and water, and they influence the radiation balance of the planet. Larch forests widely distribute throughout the North Hemisphere, e.g. occupying >40% of Russian forests, thus is global important of forested biome. However, the carbon budget of larch ecosystems has received little attention. We routinely measure net ecosystem exchange (NEE) with eddy covariance at larch forests in northern Japan, northeastern China and central Siberia. In addition, we partitioned the components of the CO_2 flux with the chamber methods, in terms of canopy photosynthesis, aboveground woody tissue respiration, understory vegetation gas exchange, total soil-CO_2 efflux, heterotrophic and root respirations. Our objectives were: (1) to quantify the contributions of CO_2 flux components to GPP; and (2) evaluate the influence of environmental conditions on CO_2 flux components.

For a 50-year-old larch plantation at Tomakomai Flux Site in Hokkaido, northern Japan, we scaled up the flux components based on the chamber measurements. In 2003, annual soil-CO_2 efflux was averaged to 9.59 tC ha^{-1}, heterotrophic respiration was about 5.47 tC ha^{-1} that accounted about 57% of the soil-CO_2 efflux, net annual CO_2 exchange of understory vegetation was about -0.39 tC ha^{-1}, annual aboveground woody tissue respiration was bout 0.75 tC ha^{-1}, and annual photosynthesis and respiration of the canopy was about -12.75 and 1.15 tC ha^{-1}, respectively. Annual GPP, NPP, NEP and ecosystem respiration for this forest was estimated to be about 13.49, 7.16, 2.04 and 11.45 tC ha^{-1}, respectively. The contribution of canopy respiration, aboveground woody respiration, root respiration and heterotrophic respiration to GPP was about 8.1%, 5.6%, 30.6% and 40.5%, respectively.

P26

LEAF PHOTOSYNTHESIS AND RESPIRATION OF A DECIDUOUS TREE (KONARA OAK) IN THE LEAFING STAGE

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Seasonal trends in leaf photosynthesis and respiration are important factors in determining the seasonality and magnitude of ecosystem CO_2 fluxes. In deciduous broad-leaf trees, photosynthetic and respiration rates change drastically in the leafing stage, so that the better understanding of those rates is required in order to study net ecosystem CO_2 exchange of deciduous forests. In this report, we present results of gas exchange measurements of leaf photosynthesis and respiration in the leafing stage.

Single-leaf gas exchange measurements were made with a portable photosynthesis system (LI-6400, LI-COR) at Fujiyoshida, Japan, from May to August 2005. From the measurements, we estimated maximum rate of carboxylation at 25℃ (V_{cmax25}) and dark respiration rate per unit area (R_d) of a deciduous tree (*Quercus serrata* Thunb., called "Konara" in Japanese), where V_{cmax25} means a measure of photosynthetic capacity at 25℃. Four branches (16, 13, 11 and 8 m high) were selected for the measurements. The LI-6400 was equipped with a LED light source and a CO_2 injector to control photosynthetically active photon flux density (PPFD) and CO_2 concentration in the chamber. In the experiments, we made light response curves of net photosynthetic rate. V_{cmax25} was estimated from saturated photosynthetic rates using Farquhar's model and R_d was assumed CO_2 exchange rate at PPFD = 0 μ mol m^{-2} s^{-1}. The CO_2 concentration and relative humidity in the chamber were kept at 360 μ mol mol^{-1} and about 60 %.

There were apparent seasonal trends in V_{cmax25} and R_d in the leafing stage. The V_{cmax25} values rapidly increased with leaf expansion. When the sharp expansion of the leaves was finished, the seasonal variation in V_{cmax25} became gradual. Although V_{cmax25} of lower branch increased faster than that of higher branch in the early period of the leafing stage, averaged V_{cmax25} of higher branch was larger than that of lower branch after the stage.

Respiration rate per unit area decreased over time in the leafing stage. Measured R_d just after leafing was higher than photosynthetic rate. After that, R_d steadily decreased for a month, even though the leaf temperature rose. Leaf respiration at 25℃ (R_{d25}) was estimated with the assumption of Q_{10} = 2.0 at each measurement, where Q_{10} is the coefficient of temperature dependency for leaf respiration rate. R_{d25} rapidly decreased with leaf expansion, which was opposite to the trend of V_{max25}. The relationship between R_{d25} and the leaf temperature clearly showed a attenuation function that indicated R_{d25} was reduced by 20 % with a 10℃ rise in temperature. Leaf respiration per unit leaf was also analysed. The trend of R_{d25} per unit leaf ($R_{d25leaf}$) showed the peak one month later from the beginning of the leafing. The time of the peak corresponded with the end of the leaf expansion period.

We found the photosynthetic and respiration rates of the deciduous tree were changed with the leaf expansion during the leafing stage. At the beginning of the growing season, leaf area could be an important parameter to determine the characteristics of leaf photosynthesis and respiration.

Keywords: Deciduous tree, Leafing stage, Photosynthetic capacity, Respiration, Single-leaf gas exchange

P27

Instrumentation and data quality assessment at Daegwallyeong CO_2 flux measurement site (DFMS) in Korea

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There is presented the instrumentation of eddy covariance technique at the Daegwallyeong CO_2 flux measurement site (DFMS) in Korea, and the initial results of applying a data quality assessment to measurements which are acquired during two experiment periods of each summer and winter season. For the data quality assessment, 1) instationarity, 2) correlation coefficient, and 3) integral turbulence characteristics (ITC) test are carried out, and then the measurements are classified to the two groups (accept or worst) according to final quality flags suggested by Foken and Wichura (1996). The acceptable group of which flag of data quality leveled from 1 to 4 is 85.4% for summer experiment and 68.1% for winter experiment, respectively. This result represents not only stationarity but also good agreement of the turbulent characteristic within similarity theory during experimental periods without the temporal difference according to diurnal or nocturnal time. The measured minimum and maximum CO_2 fluxes during the experimental periods are -27.3 μmol CO_2 m^{-2} day^{-1} (uptake) and 4.5 μmol CO_2 m^{-2} day^{-1}, (release) respectively. In theses results, the DFMS is one of the best sites for CO_2 flux measurement in order to make the information of CO_2 absorption for *Quercus mongolica* community in Korea.

P28

QUALITY CHECK OF FLUX DATA USING A MULTILAYERED CANOPY MODEL

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To obtain accurate estimates of ecosystem CO_2 uptake based on the eddy covariance measurements, the quality control of the flux data is highly important. A widely used method of the quality control is a screening of raw instantaneous data. This procedure flags questionable data, according to prescribed acceptance criteria for the level of spiky noise, absolute values of data, the range of higher-order momentum, the level of discontinuity found in a data record, and so forth. The fluxes are then calculated using data that were not flagged by this procedure. By means of these steps, observers are able to select flux data unaffected by instrumental or data recording problems. Nevertheless, there is no warranty that these selected flux data surely represent the actual ecosystem exchange. Some factors (*e.g.*, advections) may disconnect the fluxes measured at a height above the canopy from the actual exchange fluxes; or the data may be affected by some system problems that cannot be detected by the above-mentioned data screening procedure. It is, therefore, necessary to crosscheck the flux data using other independent estimates of the ecosystem exchange.

One possible method of the crosscheck is comparing the summation of flux and the net growth of ecosystem. However, this method is only applicable for a long period of time (*i.e.*, one year or longer), and the uncertainty inherent in the net growth estimates may degrade the reliability of crosscheck. Obviously, we need to have a more reliable means that can be applied for a short period of time.

We have been developing a stand microclimate model named Multilayered Implementation for Natural Canopy-Environment Relations (MINCER) as a tool for compiling individual leaf-scale measurements into a comprehensive representation of canopy-scale fluxes. This model includes all essential processes that affect the fluxes above a plant canopy, that is, biophysical, hydrological and physiological processes functioning differently at various levels inside the canopy. If the leaf-scale fluxes, the soil surface fluxes and the canopy structure are given to the model, it predicts the canopy-scale fluxes using meteorological conditions measured above the canopy. Although the output fluxes are not purely 'measurements', the comparison between the predicted and measured fluxes provides some information on the consistency of measured above-canopy fluxes with individual small-scale fluxes.

We applied MINCER to a FFPRI FluxNet site (Hitsujigaoka) established in a broadleaf forest in Sapporo, Japan. This forest is a mixture of various broadleaf species dominated by *Betula platyphylla*, *Quercus mongolica*, and *Kalopanax pictus*. In this site, measurements of canopy architecture, leaf-scale physiological measurements and the soil CO_2 flux are available as well as the eddy covariance fluxes and micorometeorological variables. The vertical profile of leaf area density was measured once for each major species, and the seasonal variation in total leaf area was monitored by the photographical technique and by measurements of PAR attenuation across the canopy. To monitor seasonal variations in the photosynthetic capacity of the dominant species, light-saturated net photosynthetic rates at two different CO_2 concentrations (360 and 1500 ppm) were measured about once per month for several leaves at each of four different heights in the canopy. From these data, seasonal variations in the vertical profile of maximum catalytic activity of Rubisco (V_{cmax}) were evaluated. The soil respiration rates were measured once per month by the closed chamber method, and the relationship between the respiration rate and the soil temperature has been established.

Using these measurements or relationships as input to the model, temporal variations in 30-min average fluxes of energy and CO_2 were simulated for three years from 2000 to 2002. For most part of the simulation period, the modeled fluxes showed good correspondence with the measured flux at least for the daytime. This agreement indicates both the model's good performance and the consistency of the eddy covariance fluxes with individual leaf-scale and soil surface fluxes. However, there were some cases when the model could not simulate the diurnal flux variations. One example is that the time trace of measured CO_2 flux was unstable and deviated from the simulated time course during and after rainfall events. We do not mean to claim that the modeled results are always true, but if we closely look at the data when inconsistency is found between modeled and measured fluxes, we can find some problems in measurements or something new that really happens.

P29

EXAMINATION OF THE HIGH FREQUENCY CORRECTION THEORIES TO THE CLOSED-PATH CO_2 FLUX MEASURED OVER A CONIFEROUS FOREST IN KYUSHU ISLAND, JAPAN

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1. Introduction

The method of high frequency correction has been one of the issues about the eddy covariance technique. Estimation of the high frequency attenuation were initially summarized by Moore (1986, Boundary-Layer Met., **37**) with simple functions, and Massman (2000, Agric. For. Met., **104**) developed it to be applicable to the closed-path system. In spite of the merit of the theoretical approach, which enables to respond to the change of wind speed, wind direction and the tube flow rate, almost all the researchers have applied an empirical frequency correction method on the basis of the discrepancy between the theoretical function and the ratio of (co-)spectra obtained from their observation system. However, in the recent study of Massman (2004, "Handbook of Micro meteorology", Kluwer academic publishers), the signal processing algorithm of an infra-red gas analyser (IRGA) was precisely described, and the volume averaging effect of the IRGA chamber was newly proposed. These factors have not been taken into account in previous studies, thus this study re-tests the theoretical approach by comparison with the field observation data obtained in the various flow rates.

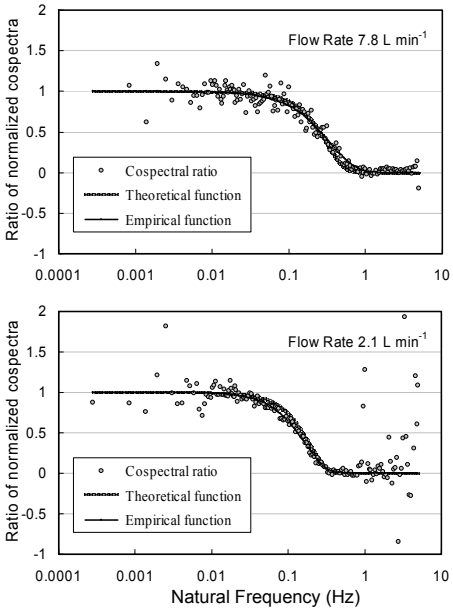
2. Site and Method

The observation site named "Kahoku Experimental Watershed (KEWS)" is a planted coniferous forest located in Kyushu Island, southeastern part of Japan (N 33°08', E 130°43'). The distribution pattern of plant species is Japanese cypress on the ridge area, and Japanese cedar (maximum 32 m height) from the valley to the hillside.

CO_2 flux measurement has been conducted by using a sonic anemo-thermometer (DAT-600, KAIJO, Japan) and an IRGA (LI-6262, LI-COR, USA). The sonic and a gas intake were installed at 50 m height, and the mutual separation was 0.5 m. The main sample tube was 57 m length and 6 mm i.d., and the sub-sample tube was 4 m length and 4 mm i.d. within which the flow rate was controlled to 2 L min^{-1}. 30 minutes block average was applied to calculate turbulence fluxes, and the tube flow delay was determined to maximize the correlation of scalars. A given 30-min data was screened by the criteria of friction velocity (0.3 ms^{-1}) and of the number of spikes (1%), before it was accepted for further analysis. Two of 1-month data sets were used for the comparison with the theoretical transfer function, and the flow rate was reduced by condensation when one of the data sets was acquired.

3. Result

Figures 1 show the ratios of normalized co-spectra of CO_2 flux to those of sensible heat flux and the theoretical functions for normal and reduced flow rates (7.8 L min^{-1} and 2.1 L min^{-1}). The exponential functions fitted to the plotted points are also represented as experimental functions. The differences of the CO_2 flux corrected by the theoretical function are on average within 0.5 % from those corrected by the empirical functions. These relatively small errors indicate that the theoretical function can be applied to the high frequency correction for the closed-path CO_2 flux, at least measured at KEWS, even when the flow rate is decreased by condensation. However, despite the two factors proposed by Massman (2004), the underestimation of the correcting factor caused by the theoretical function is proved to remain in some previous studies (e.g. Aubinet et al., 2001, Agirc. For. Met., **108**). This fact indicates that the applicability of the theoretical transfer function is somewhat limited.



Figures 1. Comparison of the ratio of normalized co-spectra with the theoretical functions for various flow rates.

P30

EFFECT OF LOCAL TEMPERATURE FLUXES IN THE VICINITY OF AN OPEN-PATH GAS ANALYZER ON THE WPL CORRECTION

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The authors often observed unrealistic downward CO_2 fluxes over a non-vegetated rice paddy in the suburb of Tsukuba, Japan (36.05°N, 140.03°E) in follow periods only when we employed an open-path eddy covariance system. We conducted a measurement campaign from March to April 2003, and found that the unrealistic downward CO_2 fluxes did not represent true transport of CO_2 and might be caused by inappropriate application of the WPL correction (Webb et al., 1980). The WPL correction postulates that all the variables involved in the correction are measured at a same point or represent the same area-averaged properties of turbulence. In the strict sense, however, the assumption is rarely satisfied in practical field measurements because the covariances in the WPL correction are measured with two different instruments, a sonic anemometer-thermometer and an open-path gas analyzer. If the open-path gas analyzer itself was a heat source, temperature fluxes measured with the sonic anemometer would differ from those at the optical path of the analyzer. This might lead to under- or over-estimate of the WPL correction term. Over the follow paddy field where only small CO_2 efflux was expected, underestimate of the WPL correction term could leave the corrected CO_2 fluxes in the daytime still downward . In order to confirm this idea by measuring local temperature fluxes in the vicinity of the open-path eddy covariance system, we conducted another experiment at the same paddy from 14 March 2005 to 7 April 2005.

We employed a sonic anemometer-thermometer (DA-600, Kaijo), two open-path gas analyzers (LI-7500, Li-Cor) and a closed-path gas analyzer (LI-7000, Li-Cor). The instrumentation and configuration were almost the same as those in the 2003 campaign. We wrapped one of the probes of the two open-path gas analyzers in a black tape made of chloroethene while keeping its optical path open in order to increase the absorptance of the probe againt short- and long-wave radiation. The taped and not taped probes are hereafter denoted by black and white probes, respectively. We measured fluctuations in air temperature at the acoustic path of the sonic anemometer and at the optical path of the black and while probes with T-type fine thermocouples (0.025 mm in diameter). Surface temperature of the probes of the gas analyzers was also monitored. These signals were sampled at 10Hz and recorded using a high-speed logger (CR5000, Campbell Scientific Inc.) All the statistics were calculated every half hour. The results obtained on March 31 are described below.

In the daytime of March 31, the mean surface temperature of the black probe was higher than that of the white one. The differences in the surface temperature between the two probes reached 1.4 °C at maximum, but they were smaller than the temperature difference between the top and the bottom parts of the white probe, which was 3.7 °C at maximum. The intra-probe differences in the white probe were also found in the nighttime with similar tendency and magnitude. This implied heat transfer from the internal infrared source to the surface at the bottom part of the probes. The standard deviation of air temperature measured at the optical path of the black probe was larger by 43% than that measured at the acoustic path of the sonic probe, and also 2.5 times as much as that measured at the optical path of the white probe However, the temperature fluxes calculated from the fluctuations in air temperature measured with the thermocouples and the vertical wind velocity (w) showed different results. The temperature fluxes calculated from temperature at the acoustic path were the largest among the three because of short separation from the path measuring w. To avoid the contamination by the different sensor separation, we introduced an equivalent temperature flux, in which the correlation coefficient between w and air temperature measured at respective paths were replaced by the correlation coefficient between w and air temperature measured at the acoustic path. The calculated equivalent temperature fluxes suggested that the local temperature fluxes as much as 50 W m^{-2} were generated at the black probe at 1100 hours on 31 March, but they were not obvious at the white probe. The temperature flux of 50 W m^{-2} is equivalent to about 2 μmol m^{-2} s^{-1} in the WPL correction and worth taking into account when we discuss the downward flux observed over the fallow paddy field.

P31

COMPARISON OF EDDY CO_2 FLUXES MEASURED WITH OPEN-PATH AND CLOSED-PATH SYSTEMS

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Long-term measurements of CO_2 flux by the eddy covariance technique using an open- or closed-path system on a tower have been performed for elucidating the carbon cycle of terrestrial ecosystems. Evaluation of the difference between annual net CO_2 ecosystem exchanges (NEE) from the open- and the closed-path data is important for site intercomparison studies. However, long-term measurements of NEE using both systems have been limited. We report the comparison of eddy CO_2 fluxes measured with open- and closed path systems for three years from 2001 through 2003.

The study site is a Japanese larch plantation in Hokkaido, Japan (42°44'N, 141°31'E). Canopy height was approximately 15-16 m and tree age was about 45 years old. Canopy LAI reached the maximum at 5.5 m^2 m^{-2} in July. Wind speed and virtual temperature were measured with a 3D sonic anemometer-thermometer (DA600, Kaijo). CO_2 and water vapor densities were measured with an open-path CO_2/H_2O analyzer (LI7500, Licor) and a closed-path CO_2/H_2O analyzer (LI6262, Licor) at height of 27 m. Data were sampled at 10Hz, and 30-min averages of fluxes were calculated. NEE was calculated as the sum of CO_2 flux and CO_2 storage change. Gross primary production (GPP) and ecosystem respiration (RE) were estimated from photosynthesis photon flux density and soil temperature using non-linear regression.

Daytime 30-min NEE tended to be more negative by about 10% for open-path than for closed-path. In contrast, nighttime 30-min NEE tended to be about 10% less positive for open-path than for closed-path.

The annual GPP estimated from closed-path data was 8–10% less negative than that from the open-path data, whereas the annual RE was 11–16% more positive for closed-path data. Consequently, the annual NEE from the closed-path data was less negative by 301–333 gC m^{-2} y^{-1}.

The bias of NEE between two systems is large and an extremely important issue. Ecophysiological approaches are needed to validate the eddy covariance technique.

P32

DATA GAP FILLING FOR ANNUAL AND MONTHLY NET ECOSYSTEM CARBON DIOXIDE EXCHANGE USING GENETIC ALGORITHM

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Selection and performance of the data gap filling method are important for the accurate and reliable estimation of annual net ecosystem carbon dioxide exchange (NEE) from long-term observations of the eddy covariance flux. The biological response models that base on well-studied environmental responses of ecosystem respiration to temperature and gross assimilation to radiation are, therefore, more reliable than the empirical techniques, and comparable among different sites. The model parameters are often determined by the non-linear regression technique, however, the technique is unable to determine all parameters for the respiration and assimilation during daytime simultaneously, and assumes an extrapolated respiration from the nocturnal observation or a constant respiration within narrow temperature ranges.

Genetic algorithm is a simple and universal optimization technique that simulates the evolution and natural selection of a organism community, and is available even for analytically insoluble problems. The simple genetic algorithm (SGA) was employed to determine the biological response model of NEE. Quality controlled datasets of carbon dioxide eddy flux, air temperature, photosynthetic photon flux density (PPFD) observed in a Japanese red pine forest and in a Siberian larch forest were used for the evaluation of this technique. Four model parameters to be determined *i.e.* ecosystem respiration at the air temperature of 0 °C (R_0), the temperature coefficient of ecosystem respiration (Q_{10}), maximum gross assimilation (A_{gmax}) and initial light use efficiency (α), were encoded into chromosomes of 16-bit long for each. The objective function of SGA to be optimized was defined as the third power of the product of correlation coefficient and inverted relative error between observed and modeled fluxes, where each statistic was scaled between 0 and 1. The SGA originally does not preserve the best-fitted individual in a generation that occasionally does not survive in the next generation. To prevent this loss, the best-fitted individual was immigrated unconditionally into the new generation. Initial population, crossover rate and mutation rate were set to 1000, 0.5 and 0.2, respectively, and each trial computed up to 100 generations. The model was evaluated monthly and 20 trials were performed for a monthly dataset.

The best-fitted estimations of the NEE model parameters among 20 trials for each month were used for the evaluation. In the Japanese red pine forest, the standard error in NEE was 0.6 μmol m^{-2} s^{-1} in average and ranged between 0.4 (October 2004) and 1.2 μmol m^{-2} s^{-1} (June 2005), and the determination coefficient (r^2) was 0.76 in average and ranged between 0.65 and 0.88. Estimated Q_{10} and A_{gmax} showed obvious seasonal change, which was corresponded with monthly mean air temperature. The large Q_{10} in a hot season suggests large errors in the ecosystem respiration and, consequently, in the gross assimilation if it was estimated using only nocturnal observations. Solutions by the SGA generally vary more or less for the trials and are not deterministically unique. However, the estimates of NEE parameters did not change so much among the 20 trials for each month, and the solutions by this technique was supposed to be sufficiently optimized.

The modeled NEE for the Siberian larch forest also showed a good accuracy. This forest stand often catches a severe drought in summer, and the significant depressions both in photosynthesis and ecosystem respiration have been observed. Linear trends of the Q_{10} and A_{gmax} to the vapor pressure deficit were modeled and encoded in additional three chromosomes in the SGA. This new model well described the drought effect on NEE in mid summer, and the accuracy was slightly improved.

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P33

DIURNAL AND SEASONAL VARIATIONS IN CO_2 EXCHANGE OVER A *GMELIN* LARCH FOREST ON CONTINUOUS PERMAFROST OF THE CENTRAL SIBERIA

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The magnitude of ecosystem CO_2 exchange between the boreal forests and atmosphere is of particular interest because of the wide coverage of the forests. The boreal forests are comprised primarily not only of evergreen conifer but also of deciduous conifer, Larch. Larch forests distribute widely over central to eastern Eurasia. The larch species form forests even over continuous permafrost in North-West Eurasia. Now, the measurement network on carbon balance over the larch ecosystems is very sparse, and the representative magnitude of CO_2 exchange was not quantified. The above background, ecological investigations have been continued and micro-meteorological measurements initiated at some larch forests in Russia, China, and Japan.

Recently, we are able to carry out long-term micro-meteorological measurements at remote sites because of technology developments in micro-computer, data-loggers, solar power-generators, high-quality batteries and sensors for surface meteorology. Based on this technological background, half-hourly CO_2 exchange between a *Gmelin*-larch forest ecosystem and atmosphere, was measured during a whole growing period of the tree at Central Siberia, using the eddy covariance method. The whole measurement integration system could be stably operated.

Diurnal patterns with daytime uptake in CO_2 exchange were observed in early June when the soil was almost frozen. The maximum half-hourly net CO_2 uptake rate appeared mainly between late of June and the end of July. In early September, the net CO_2 exchange was positive (release from the surface) and it's diurnal variation was not clear.

This study was funded partially by the Global Environment Research Fund.

P34

Author: Larry Lopez

Transpiration, water potential and stomatal conductance of *Larix cajanderi* under non-limiting soil moisture, Central Yakutia, Eastern Siberia.

Two plots were set in a larch (*Larix cajanderi*) forest one under non-limiting soil water conditions (irrigation regime applied) and the other under natural precipitation regime in Central Yakutia, Eastern Siberia. Sap flow rate values were scaled up to stand transpiration and utilized for calculations of canopy conductance. The calculated values provided the basis to estimate Potential transpiration using maximal canopy conductance as a function of vapour pressure deficit. For non limiting water conditions canopy conductance was 2.57 and about 3.11 mm s^{-1} for natural conditions. Predawn water potential was not followed by variations of stomatal conductance or leaf transpiration. Tree transpiration response to irrigation was immediate whereas at leaf level the effects were observed after 3 to 4 days. This lag suggests that extra water in the soil is first used in replenishing tree compartments rather than giving it all to transpiration. The percentage of increased transpiration ranged between 20 to 50 % following the days after irrigation. The upper 10 cm of soil layer played an important role in the control of transpiration. When soil moisture at this layer is not a limiting factor canopy conductance and consequently transpiration can be estimated as a function of VPD. The total transpiration during the growing season 2004 was merely 70 mm. Despite irrigation, the total amount of transpiration at both plots was not significantly different.

P37

ECOSYSTEM CO_2 FLUX OVER TWO YEARS FOR A 200-YEAR-OLD CHINESE BROAD-LEAVED KOREAN PINE MIXED FOREST

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Long-term measurement of carbon metabolism of old-growth forests is critical to predict their behaviors and to reduce the uncertainties of carbon accounting under changing climate. Eddy covariance technology was applied to investigate the long-term carbon exchange over a 200 year-old Chinese broad-leaved Korean pine mixed forest of Forest Ecosystem Open Research Station of Changbai Mountains (128° 28'E and 42° 24' N, Jilin Province, P. R. China), Chinese Academy of Sciences, since August 2002. This paper reports the result on (1) Regulation of environmental factors on phase and amplitude of ecosystem CO_2 uptake and release; (2) sink/source status on the data obtained with open-path eddy covariance system and CO_2 profile measurement system from Jan. 2003 to Dec. 2004. Corrections due to storage and friction velocity were applied to the eddy carbon flux.

The most significant difference between 2003 and 2004 were precipitation and temperature. The precipitation of 2004 was 707.3 mm and very close to 693.9 mm, the averaged value between 1982 and 2004, while the precipitation of 2003 was 538.4 mm. Atmospheric and soil temperature at 5 cm depth of 2004 were 0.7 and 0.5 C higher than that of 2003 separately. The forest was a net sink of atmospheric CO_2 and sequestered - 449 gC m^{-2} during the study period, and -278 and -171 gC m^{-2} for 2003 and 2004 separately. F_{GPP} and F_{RE} over 2003 and 2004 were -1332, -1294 gC $m^{-2.}$ and 1054, 1124 gC m^{-2} separately. The seasonal trends of gross primary productivity (F_{GPP}) and respiration (R_E) followed closely with the change in LAI and temperature. The summer is the most significant season as far as ecosystem carbon balance is concerned. The 90 days of summer contributed 66.9, 68.9% of F_{GPP}, 60.4 and 62.1% of R_E of whole year. This study shows that old-growth forest can be strong net carbon sink of atmospheric CO_2.

P38

CO_2 EXCHANGE OF A LARCH FOREST ECOSYSTEM IN NORTHEAST CHINA

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Larch forest is believed to take an important role on the global ecosystem carbon budget due to its vast distribution area. It is a dominant forest type in Siberia, covering an area of 277.5×10^6 ha. Northeast China is the southern distribution edge of Dahurian larch (*Larix gmelinii*), which is covering as large as 15.6×10^6 ha in area as a critical natural forest ecosystem in this region. The aim of this study is to evaluate the carbon budget of larch forest ecosystem and also the possible influence of environmental variables during the period from October 2003 to September 2004.

This study was carried out in an artificial larch (*Larix gmelinii*) forest, planted in 1969, at Laoshan site (LS, 45°20' N, 127°34'E) in northeast China in May 2002. Dahurian larch is the dominant canopy species and comprises 88% in basal area and 81.3% in individual number. The mean canopy height of the forest is about 17 m. The elevation of the tower site is about 370 m above sea level. Closed path eddy covariance technology was used for CO_2, water vapor and energy fluxes measurement. The measurement height was 29 m above ground and about 12 m high above the canopy layer. Wind velocity and virtual temperature were measured using a three-dimensional ultrasonic anemometer. Variation of CO_2 and H_2O concentrations were measured with a closed path CO_2/H_2O infrared gas analyzer. The raw data was sampled at a rate of 10 Hz and CO_2 flux (Fc) was calculated half-hourly based on a series of quality control rules. The carbon storage (Fs) under the canopy was estimated from the temporal difference in CO_2 concentration measured at the flux plane. The net ecosystem CO_2 exchange (NEE) is calculated as the sum of Fc and Fs.

The larch ecosystem released 0.3 ~ 3 gC m^{-2} d^{-1} CO_2 during the leafless season from mid October 2003 to mid April 2004. While in growing season, the ecosystem strongly assimilated CO_2 from the ambient atmosphere. The maximum carbon uptake rate was about 8.0 gC m^{-2} d^{-1} for daily average value, but exceeded 30 μmol m^{-2} s^{-1} for the half-hourly mean value. The ecosystem respiration mainly determined by temperature, but seemed less affected by soil water content. The ecosystem photosynthesis activity mainly controlled by the absorbed photosynthetic active radiation (APAR), but it was also greatly influenced by vapor pressure deficit (VPD). The carbon sequestration ability of the larch plantation peaked in June, and totally absorbed 110 gC m^{-2} mon^{-1} (with friction velocity (u*) > 0.2 m s^{-1}) or 140 gC m^{-2} mon^{-1} (with u* >0 m s^{-1}). During this study period, the larch ecosystem acted as a carbon sink and sequestered 120 gC m^{-2} yr^{-1} (u* > 0.2 m s^{-1}) to 190 gC m^{-2} yr^{-1} (u* > 0 m s^{-1}). This result is comparable with that observed in a Japanese larch forest at Tomakomai flux site in northern Japan, where the larch ecosystem sequestered 141 to 240 gC m^{-2} yr^{-1} (Wang et al, 2004), but it is much higher than that in Siberia and Mongolia regions, where the larch forest ecosystems absorbed 90~85 gC m^{-2} yr^{-1} (Hollinger et al., 1998; Li et al., 2005).

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SEASONAL VARIATION IN CO_2 AND H_2O FLUXES IN A YOUNG LARCH PLANTATION IN NORTHERN JAPAN

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In order to evaluate the change in the watershed scale carbon and water cycles according to the tree growth, 2-year old hybrid larch (*Larix gmelinii*×*L. kaempferi*) was planted in an area of 13.7 ha in October 2003, 8 month after the clear-cutting of trees in the area, and flux observation by eddy covariance technique and watershed-scale water balance evaluation using an observation weir were conducted. The study site was located on a flat terrace in the Teshio Experimental Forest, Hokkaido University (45°03'N, 142°06'E, 66 m asl). During January to March 2003, trees in the area were clear-cut, and in October 2003, *Sasa* bamboos (the above ground biomass is 6–12 tC ha^{-1}) were strip-cut into 4 m rows (a half of the clear cut area) and ca. 30000 saplings (ca. 0.04 tC ha^{-1}) of hybrid larch were planted.

Closed-path eddy covariance technique was applied to evaluate the carbon and water fluxes at 4.6m height. A sonic anemometer and CO_2/H_2O fluctuation meter were used for the evaluation. Meteorological measurements included air temperature and relative humidity, net radiation, photosynthetically active radiation, and precipitation. Underground, soil temperature and water content profiles, and soil heat flux were measured at five points. Water table of the stream in the watershed (8 ha) was monitored and the discharge rate was evaluated using a water table-discharge rate relationship.

The clear-cutting of trees decreased the sequestration capacity of this ecosystem. *Sasa* bamboos still have large biomass and the half-hourly NEE often indicates negative values (carbon sequestration) in the daytime from July to September (-5 μmol m^{-2} s^{-1} at its maximum). However, because of the large NEE in the nighttime, the daily NEE kept positive values even in that situation (ca. 0.2 mol m^{-2} day^{-1}). The daily emission rate of the young larch plantation in the growing period of 2004 was almost the same level with that of the *Sasa* dominated ecosystem after the tree cutting in 2003, in spite of the strip cutting of *Sasa* bamboos and planting of the larch saplings. On the other hand, evapotranspiration rate in 2004 (ca. 250 mm $year^{-1}$) recovered to the same level with that in the mixed forest in 2002 and ca. 3 times larger than that in 2003. Watershed scale water balance observation also revealed the increase in the evapotranspiration rate and the decrease in the run off rate of the stream in 2004. We attributed the increase in the evapotranspiration rate partly to the acclimation in the transpiration capacity of *Sasa* bamboos. In conclusion, the young larch plantation is still net source of the carbon, however, the distinct decrease in the evapotranspiration rate caused by the tree cutting recovered to the same level with that in the mixed forest in the next year after larch plantation.

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SEASONAL AND INTER-ANNUAL CHANGES IN CARBON BALANCE FOR A BROADLEAVED DECIDUOUS FOREST IN SAPPORO, NORTHERN JAPAN

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A long-term observation of CO_2 exchange was conducted above a broadleaved deciduous forest in Sapporo, northern Japan. In this study, we report seasonal and inter-annual changes in carbon balance based on the eddy covariance flux measurements.

The observation has been conducted in the Sapporo observation site, located in the Hitsujigaoka Experimental Forest (42°59'N, 141°23'E, 180 m a.s.l.) of Hokkaido Research Center, Forestry and Forest Products Research Institute (FFPRI, Japan). The experimental forest is a secondary forest after a forest fire occurred about 100 years ago. Dominant species of the forest canopy are Japanese white birch and Mizunara oak. The average canopy height is about 20 m. This site is a part of the FFPRI-FluxNet (CO_2 flux monitoring network). Fluxes above the forest were measured by the eddy covariance method using a 3-D sonic anemothermometer (DAT-600, KAIJO) and a closed-path infrared gas analyzer (IRGA, Li-Cor Li-6262) at the height of 28.5 m. The CO_2 storage change below the eddy-flux level (*Fs*) was measured using an IRGA, and meteorological elements were also measured. In the process of eddy flux calculation, we applied quality control procedures (Ohtani et al. 2005) to check raw eddy fluctuation data.

To estimate net ecosystem production (*NEP*), ecosystem respiration (*RE*) and gross primary production (*GPP*) of the forest, a simple empirical model was applied. The model is as follows.

$$RE = a \cdot \exp (b \cdot Ts5) \quad (1)$$

$$GPP = Agmax \cdot PAR / ((Agmax/c) + PAR) \quad (2)$$

$$NEP = GPP - RE \quad (3)$$

(*a, b*, *Agmax* and *c*, coefficients; *Ts5*, soil temperature (°C) in the depth of 5 cm; *PAR*, photosynthetically active radiation)

The coefficients, *a* and *b* were determined by curve fitting of eq. *(1)* between observed nighttime *NEE* (net ecosystem exchange, determined as the sum of CO_2 flux and *Fs*) and soil temperature on condition that the friction velocity (*U**) is greater than 0.4 m s^{-1}.

Annual *GPP*, *RE* and *NEP* estimated by the model and the temperature sensitivity of *RE* (*Q10*) are indicated in Table 1. Averages of annual *GPP* and *RE* were about 1300 and 950 g C m^{-2} $year^{-1}$ respectively, and annual *NEP* ranged from 237 to 431 g C m^{-2} $year^{-1}$. The *Q10* was largely different in each year. We don't think that the *Q10*, which influences estimation of *RE*, widely changes every year, so further consideration is necessary for *RE* estimation.

Table 1. Annual *GPP*, *RE*, *NEP* (g C m^{-2} $year^{-1}$) and *Q10* value (temperature sensitivity of respiration)

Year	*GPP*	*RE*	*NEP*	*Q10*
2000	1231	994	237	1.86
2001	1289	970	319	1.79
2002	1313	882	431	2.88
2003	1357	951	406	2.19

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A YEARLONG OBSERVATION OF ECOSYSTEM CARBON CYCLE IN JAPANESE RED PINE FOREST

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Recently, carbon cycle in the typical ecosystems is studied worldwide. Most of red pine forests (*Pinus densiflora*) in Southwest Japan are formed as the secondary forests in which broadleaf trees are mixed, and are different from those in the continental cool temperate zone. In this study, we are observing ecosystem carbon cycle including various carbon compartments in a Japanese red pine secondary forest.

The observation site is located in Mikiyama forest park, Hyogo, Japan. The average height of trees was 8m, and tree species in the stands consisted of Japanese red pine (*Pinus densiflora*) and broadleaf trees; *Clethra barbinervis*, *Quercus serrata* and so on. CO_2 flux above the forest was measured continuously with the eddy covariance method using a sonic anemometer and an open-path IRGA installed on a tower of 13 m tall since September 2004. Air temperature and photosynthetic photon flux density (PPFD) were also measured. In the flux calculation, linear trend removal for the CO_2 concentration and WPL correction were applied and the less reliable values were removed by the stationarity and standard deviation tests, and the flux footprint test. Ecosystem respiration (R_e) and gross photosynthesis (A_g) were estimated as the functions of air temperature and PPFD, and the data gap of NEE was interpolated by the estimates. Soil temperature at 5 cm deep and soil respiration (R_s) were measured using automatic ventilation closed-chambers. Litter fall was measured every month using ten traps. Above ground tree biomass and soil organic carbon content was measured in December 2003 and 2004

Monthly total NEE of the red pine forest was negative in all month showing the absorption of CO_2 during measurement period. Monthly total R_e and A_g estimated by the interpolation functions changed largely with the season, and both maximum R_e and A_g appeared in September, and minimum in February. Seasonal variation of R_e correlated to air temperature. A_g decreased from September through December and increased from February through April, which is similar to the seasonal course of PPFD, however, A_g reached the minimum in February regardless of marginally increasing PPFD from December to February. Estimated maximum gross photosynthesis (A_{gmax}) depended on air temperature strongly and it reached the minimum value in the January and February when monthly mean temperature was the lowest. A sudden decrease of A_g in October 2004 was probably because of severe leave fall by a strong typhoon attacked the site. Therefore, the seasonal variation of NEE from autumn to spring is not simple because its components A_g and R_e individually depend on the different environmental elements and disturbances.

Seasonal variation of R_s was closely related to the variation of soil temperature. R_s increased also with soil moisture, and monthly R_s was very high in September and October 2004 when monthly precipitation was large. In October, the fraction of R_s to R_e was the maximum during the measurement period. Carbon stock in aboveground biomass was estimated 53.4 and 63.0 tC ha^{-1} in December 2003 and 2004, respectively, and annual growth of aboveground biomass was estimated 35.0 mol m^{-2}. Litter fall was the most from September to November 2004 consisting of the leaves and fruits of trees and shrubs, and was the second most in January 2005 consisting of the bark and twig of red pine.

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LONG-TERM OBSERVATION OF MICROMETEOROLOGICAL NEP IN FUJIYOSHIDA SITE

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A long-term monitoring of net ecosystem production (NEP) has been conducted in Fujiyoshida forest research site (FFPRI FluxNet). The site is located on a gentle lava slope of Mt. Fuji covered with 90 year old Japanese red pine forest. Above canopy CO_2 flux (*Fc*) was measured by eddy covariance method with a sonic anemometer (DA-600/KAIJO) and a closed-path infrared CO_2 analyzer (LI-6262/LI-COR). Raw fluctuation data were recorded at 5Hz by a data logger with a magneto-optical disk (DRM3/TEAC). CO_2 Storage change within the canopy (*Sc*) was measured with another CO_2 analyzer (LI-6262/LI-COR). Then the net ecosystem exchange of CO_2 (NEE) was obtained by NEE = *Fc* + *Sc* at every 30 minutes. After the data quality control, the semi-empirical parameterization of the nighttime ecosystem respiration and the gross primary production was applied; finally continuous data of the net ecosystem production (NEP; NEP = - NEE) were obtained.

The CO_2 release from the forest ranged from 1 to 2gCO_2m^{-2}d^{-1} continued through the mid winter, though the daily NEP showed almost absorption in the remaining period. This suggested that the dormant period of the coniferous forest was shorter than that of the deciduous forest. Although the magnitude of the daytime NEP increased from late spring to summer, the daily sum of NEP decreased, because the ecosystem respiration also increased in the course. Among the years from 2000 to 2003, the inter-annual variation in NEP was large, i.e. the maximum was about 30% lager than the minimum. The difference of the annual NEP induced by the balance of the ecosystem respiration and the assimilation was mainly affected by the inter-annual variation of the seasonal radiation and the temperature.

From 2000 to 2002, the solar radiation had large year-to-year variation in almost all months. The monthly air temperature also showed year-to-year variation, but was relatively low from May to October. The monthly gross ecosystem assimilation also had large inter-annual variation throughout the year. Even in winter, the assimilation occurred if air temperature became positive. But the ecosystem respiration was relatively more consistent than the assimilation, because the air temperature behaved similarly among years in summer, and the forest was snow covered in winter when the inter-annual variation of the air temperature became large.

In 2003, the monthly solar radiation and the air temperature were extremely low in July in Fujiyoshida because of the distinct Asian monsoon. In this year, the sunshine duration in summer season observed in 10 meteorological stations in Eastern Japan updated the lowest record. At which time in the Fujiyoshida site, more than 100 gCm^{-2}month^{-1} of the gross ecosystem assimilation was reduced, alternately about 80 gCm^{-2}month^{-1} decrease of the ecosystem respiration made up the deficit.

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Annual variation in carbon flux and relationships between carbon flux and impact factors in a tropical seasonal rain forest

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Abstract: Two years eddy covariance measurements of above- and below-canopy carbon fluxes and the static opaque chamber and gas chromatography technique measurements of soil respiration for three treatments (bare soil, soil+litterfall, soil+litterfall+seedling) were carried out in a tropical seasonal rain forest. In addition, data of photosynthesis of dominated tree species and shrubs, leaf area index, litter production and its decomposing speed, precipitation, soil moisture, soil temperature and photosynthetic photon flux density within the forest were all measured at the same time. Data from January 2003 to December 2004 are used to present annual variability of carbon flux and relationship between carbon flux and impact factors. The results showed that, carbon flux of this forest was smaller and annual variability was not great, however, it presented special tendency of annual variation, which exhibited above-canopy carbon fluxes were negative in dry season (November-April) and forest is a carbon sink; while above-canopy carbon fluxes were mainly positive in rainy season (May-October), and forest is a weak carbon source; carbon flux of this forest presented an opposite annual dynamic tendency composed to other forest ecosystems. Carbon flux has obviously diurnal variations in this tropical seasonal rain forest. Above-canopy carbon fluxes were negative in the daytime and absolute values were bigger, which presented carbon sink effect; while in the nighttime, carbon fluxes were mainly positive and it presented effects of carbon source; moreover, carbon fluxes were greater in the fore-midnight of the fog-cool and dry-hot season. Below-canopy carbon fluxes were almost positive in every season and they were greater in the daytime, which showed that CO_2 was transferred upwards in the forest, and it presented more significant in the rain season than that in the dry season. Dominated tree species have greater photosynthesis capability, which have a great effect on above-canopy carbon flux. There existed the significant correlation relationship between above-canopy carbon flux and rate of photosynthesis of tree species. There also exhibited the significant correlation relationship between above-canopy carbon flux and rate of photosynthesis of shrub; however, it only did in the dry-hot season that the significant correlation relationship between the ground carbon flux and rate of photosynthesis of shrub was in existence. Soil respiration of three treatments possessed markedly seasonal dynamic; in addition, above- and below-canopy carbon fluxes all have good correlation relationship with soil respiration, also did with litterfall production, litterfall decomposing rate, precipitation, and soil moisture and temperature. This research showed that carbon flux was impacted by many factors in this forest. Unique climate, soil environment, and mutual actions between these two factors and plant physiological actives are all the factors to impact annual variation of carbon flux in tropical seasonal rain forest. A primary statistical result of this study showed that above-canopy carbon flux in this forest presented carbon source or sink effects in different seasons, and it is a carbon sink at the scale of a year.

Keyword: Carbon flux, annual variation, impact factors, tropical seasonal rain forest, Xishuangbanna

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Carbon flux observation in the tropical seasonal forests and tropical rain forest

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Our knowledge of the sources and sinks of CO_2 is not sufficient in the tropical area where sequestration of CO_2 by forests seems to be large. Generally, there are two types of forests in the tropical humid areas, rain forests and seasonal forests. Sakaerat site belongs to Dry Evergreen Forest (seasonal forest). Maeklong site belongs to Mixed Deciduous Forest (seasonal forest). Bukit Soeharto site belongs to secondary tropical rain forest.

Sakaerat tower is located in the comparatively flat top whose inclination is 6m/100m of the table-like hill. Maeklong tower is located in the complicated terrain. Bukit Soeharto tower is located in the secondary forest where young *Macaranga* species grow rapidly after fire caused by drought related with ENSO event.

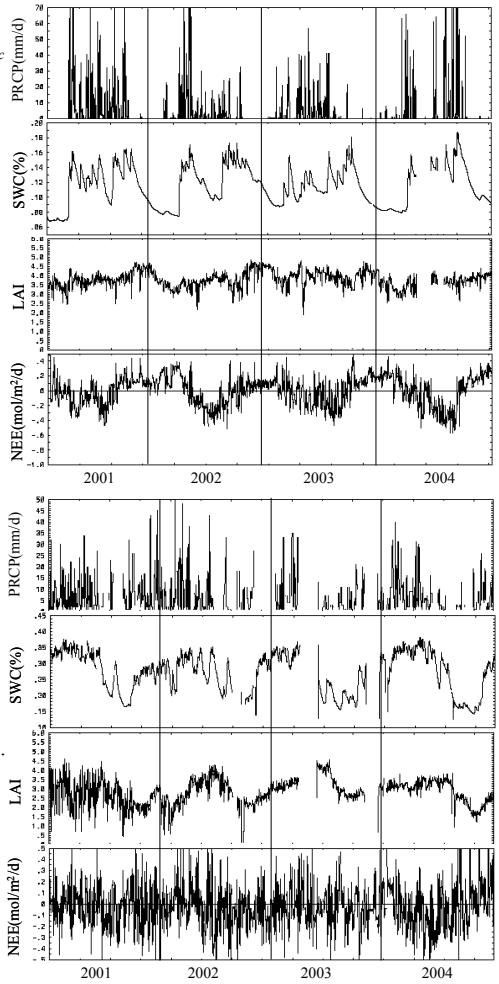
The data gap filling was made by parameterization. We applied the characteristics of photosynthetic light curve at individual leaf level to the canopy level, since we considered photosynthetic light curve of canopy as an analogy of that of individual leaf. Gross primary production GPP was parameterized by the following non-rectangular hyperbola,

$$GPP = (\phi\, APAR + GPP_{\max} - ((\phi\, APAR + GPP_{\max})^2 - 4\phi\, APAR\, \theta\, GPP_{\max})^{0.5}) / 2\theta - R_{ec}$$

Here, ϕ is the quantum yield, GPP_{max} the maximum rate of gross primary production, θ the efficiency of absorption, APAR the absorbed photosynthetic active radiation, R_{ec} the ecosystem respiration. It seems that parameterization by generally used rectangular hyperbola leads to overestimation for ϕ and GPP_{max}.

Figure (top) shows the daily trends of precipitation PRCP, soil water content SWC, Leaf area index LAI, and Net ecosystem exchange NEE at Sakaerat for the four years. In spite of the evergreen forest, there is a seasonal change in LAI. The annual NEE was -13.5, -12.7, -14.9, and -13.0 t C ha^{-1} in 2001, 2002, 2003, and 2004, respectively. Tree census data (Kanzaki et al, 1995) showed this site was a mature forest. One of the reasons caused large negative NEE for this forest is probably due to the ecosystem respiration (R_{ec}) which is the sum of plant and non-plant respiration outflows from this community. The relationship between NEE and friction velocity u_* during the nights showed NEE increased with u_*, and did not maintain at a constant value at large u_*. We estimated R_{ec} in the case when yearly accumulated NEE for each year becomes zero (NEE in Figure for Sakaerat). In that case, R_{ec} (μmol m^{-2} s^{-1}) was 9.6, 10.2, 11.3, and 9.9 in 2001, 2002, 2003, and 2004, respectively.). There was the dependency of GPP_{max} on soil moisture (SWC) at Sakaerat and Maeklong.

Figure (down) shows the daily trend of parameters at Bukit Soeharto. In spite of the rain forest climate, there were dry season from July to October for every year. It seems that NEE had large negative value in the beginning of dry season, and absorption of CO_2 became small in the latter stage of dry season.



P45

Effects of disturbances and the ENSO drought on the micrometeorology and radiation characteristics of a tropical peat swamp forest

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Tropical peat swamp forests are widely distributed in low plains in Southeast Asia, where a large amount of organic carbon has accumulated as peat. Recently, land-use changes following deforestation and drainage have disturbed their environment, and drought due to the El Nino Southern Oscillation (ENSO) leads to large-scale peatland fires. Such disturbance and consequent fires bring a large amount of CO_2 emission into the atmosphere and a change in the energy balance of land surface, whereas we have little information on the micrometeorology of tropical peat swamp forests. Therefore, to investigate the effects of disturbance and the ENSO drought on the micrometeorology, we have continuously measured micrometeorology at a forest (F-site) since July 2001 and a deforested area burnt in 2002, an ENSO year, (B-site) since April 2004; both sites are located on a tropical peatland in Central Kalimantan, Indonesia. Moreover, we compared the radiation characteristics of the land surface of the sites. At F-site, micrometeorology was measured at a height of 41−42 m above forest canopy on a tower. On the other hand, the measurement was made at 1.5−3 m at B-site. Using radiation measurements, we calculated broad-band NDVI (Huemmrich et al., 1999) as an index of radiation characteristics.

Precipitation data showed that the dry season began in May and lasted for about 6 months until October on average, judging from a threshold of monthly precipitation of 100 mm. In 2002, the dry season had less precipitation than those of 2003 and 2004 because of the ENSO drought. During the dry season in 2002, low PPFD was also measured in spite of fewer clouds. This unexpected low PPFD was caused by smoke emitted from widespread peatland fires. In September, monthly mean CO_2 concentration increased to 401.6 ppmv in 2002, which was considerably higher than 387.5 ppmv in 2003.

Figure 1 shows a seasonal variation in NDVI at F-site from 2001 through 2004. NDVI of the forest decreased during the dry season except in 2003. In 2002, the decrease was largest and continued until the end of October. The difference in the seasonal pattern of NDVI would be related to the water status of trees and/or LAI. Figure 2 shows seasonal variations in water table and NDVI at B-site from April 2004 through March 2005.Water table went under the ground at mid-June and reached the minimum of -0.82 m at the end of October. Contrastively, NDVI continued to increase during the dry season; its monthly mean value increased from 0.47 in July to 0.60 in November. This increasing NDVI reflected the re-growth of grass vegetation. Scattering NDVI before June and after December was caused by open water on the ground.

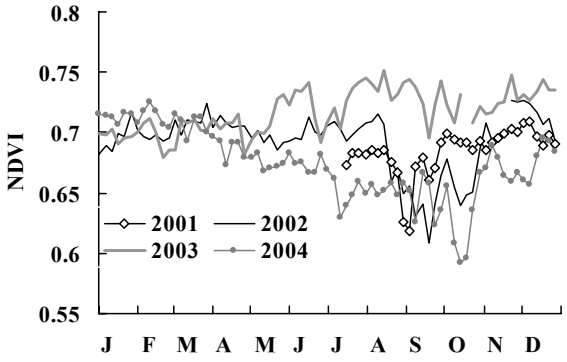

Fig.1 Seasonal variation in NDVI at F-site from 2001 to 2004 (5-day means)

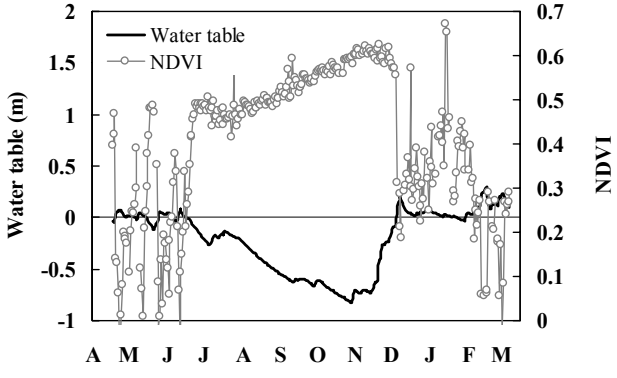

Fig.2 Seasonal variations in water table and NDVI at B-site from April 2004 to March 2005

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CARBON DIOXIDE EXCHANGE MONITORING AND RESEARCH PROGRAMS AT THE HUNGARIAN TALL TOWER SITE

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The mixing ratio and the surface-atmosphere exchange of carbon dioxide have been monitored at different elevations on a tall tower in West Hungary (Hegyhátsál, 46°57'N, 16°39'E, 248 m asl) since 1994 and 1997, respectively. The vertical mixing ratio profile measurements along the 115 m tall tower has been completed with occasional aircraft measurements up to 3000 m above the ground. The poster presents the Hungarian tall tower site and the temporal variation of carbon dioxide observed here. The research activities that are related to the measurement site are also presented together with the linkages with the core measurements. We discuss the region of influence determining the mixing ratio variability, the so-called concentration footprint, as well as that of the flux measurements. The environmental factors governing the net ecosystem exchange (NEE) of the vegetation are analyzed by means of a process oriented ecosystem simulation model. It might be used to estimate the future behavior of the region as the climate is changing. On the basis of the measurements at Hegyhátsál a boundary layer model has been developed which can give rough surface-atmosphere carbon dioxide flux estimate for sites where only surface mixing ratio monitoring is available.

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FLUXES OF CARBON DIOXIDE, WATER VAPOR AND ENERGY OVER A TEMPERATE GRASSLAND IN CENTRAL JAPAN FROM AUTUMN TO EARLY SUMMER

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To investigate the influence of manure application on greenhouse gas budget of managed grasslands, we started an experiment at four grassland sites in Japan. At each site, two plots were provided for the experiment, one for manure application (M plot) and the other for chemical fertilizer application (F plot), and fluxes of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are measured at each plot. In this paper, we focus on CO_2, and report results of eddy covariance measurements of CO_2, water vapor and energy fluxes at one of the four sites in central Japan. The measurements were conducted from September 2004 to July 2005 at a grassland in National Institute of Livestock and Grassland Science, Nasushiobara, Japan (36°55'N, 139°58'E). The annual temperature and precipitation of this site is about 12.0°C and 1600 mm, respectively. The vegetation is dominated by orchard grass (*Dactylis glomerata* L.) and Italian ryegrass (*Lolium multiflorum* Lam.). Manure was applied on M plot after the last harvest of 2004 (mid-November). The eddy covariance system, which consisted of a sonic anemometer (CSAT3, Campbell Scientific) and an open-path infrared gas analyzer (LI-7500, LI-COR), was installed at each plot with instruments to measure other meteorological variables.

Seasonal changes in fluxes of latent heat (*LE*), sensible heat (*H*) and CO_2 over the grassland of the two plots were quite similar even after the manure application. From the last harvest of 2004 to mid-March 2005, daily *LE* was kept constant at a value of around 1.9 MJ m^{-2} d^{-1} (equivalent to 0.8 mm d^{-1} in evapotranspiration rate (*ET*)). On the other hand, daily *H*, which was almost zero until late-January, took positive value from February to mid-March, and the Bowen ratio for midday increased from 0.6 to 1.4. CO_2 flux temporally changed from negative to slightly positive after the last harvest of 2004. CO_2 uptake was thereafter kept almost at a constant level, 0.6 g C m^{-2} d^{-1} on average, during this period. Even in mid-winter, diurnal variation of CO_2 flux was observed, and daytime CO_2 flux responded to changes in incident photosynthetically active photon flux density. From mid-March to the first harvest of 2005 (mid-May), daily *LE* and CO_2 uptake increased markedly up to 13.0 MJ m^{-2} d^{-1} (5.3 mm d^{-1} in *ET*) and 9.7 g C m^{-2} d^{-1}, respectively. In contrast, daily *H* decreased gradually to a constant level of 0.5 MJ m^{-2} d^{-1}. After the first harvest of 2005, temporal release of CO_2 to the atmosphere was observed, but with growth of aftermath CO_2 uptake recovered rapidly to the pre-harvest level just 2 weeks later. Fluxes showed similar trends to the previous period: daily *LE* and CO_2 uptake increased up to 13.1 MJ m^{-2} d^{-1} (5.4 mm d^{-1} in *ET*) and 10.7 g C m^{-2} d^{-1}, respectively, and daily *H* decreased to a constant level of 0.6 MJ m^{-2} d^{-1}.

In summary, this study showed seasonality of CO_2, water vapor and energy fluxes over the temperate grassland in central Japan, and that the influence of different treatment on CO_2 flux was insignificant. Furthermore, although the available data were limited, the results suggest that the grassland in central Japan may act as a CO_2 sink throughout the year.

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EXCHANGE OF CARBON DIOXIDE AND WATER VAPOR BETWEEN GRASSLANDS AND THE ATMOSPHERE AT FOUR HAY MEADOW SITES IN JAPAN FROM AUTUMN TO SPRING

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In order to investigate how stable manure application affects greenhouse gas emission from Japanese managed grasslands, we started an experiment at four hay meadow sites (Fig. 1) from 2004. At each site, two adjoining plots were provided for the experiment: one for stable manure application, and the other for chemical fertilizer application. Nitrous oxide and methane flux densities are measured on selected days by the static chamber method, while flux density of carbon dioxide (CO_2) is monitored continuously from September 2004 by the eddy covariance method. From the results of the first year, we present seasonal variations of CO_2 and water vapor fluxes from autumn to early spring when plant activity is relatively low. Because the main objective of this paper is to describe seasonal trends of CO_2 and water vapor fluxes at each site and their inter-site differences rather than to assess the effect of stable manure application on CO_2 exchange, we selected one of the two experimental plots from each site to show the results.

Net ecosystem CO_2 exchange (NEE) and evapotranspiration rate (ET) at the four sites exhibited high-degree of seasonality and inter-site variabilities. At Kobayashi (KBY) site in southwestern Japan, daily CO_2 uptake of 4-5 g C m^{-2} d^{-1} and ET of 1.4 mm d^{-1} were observed in mid-winter. With growth of grasses from mid-March to harvest in late April, daily CO_2 uptake and ET showed marked increases, which were followed by temporary post-harvest CO_2 release in late April. At Nasushiobara (NSS) site in central Japan, ET of 0.8 mm d^{-1} on average was observed throughout the winter. Daily NEE at NSS site in mid-winter was –0.2 g C m^{-2} d^{-1}, indicating that daytime photosynthetic CO_2 uptake was almost balanced by ecosystem respiration. Both CO_2 uptake and ET increased with growth of grasses from mid-March to harvest in mid-May. At Shizunai (SZN) site in central Hokkaido, the grassland was generally dormant in CO_2 and water vapor exchange during the snow cover period. Daily latent heat flux started an increase prior to snowmelt in late March, while daily NEE was kept around zero until late April. Similar seasonal trends in energy and CO_2 exchange were observed at Nakashibetsu (NKS) site in eastern Hokkaido, but unexpected CO_2 emission of 0.6 g C m^{-2} d^{-1} on average was observed from snow-covered grassland throughout the winter. The total NEE and ET from October 2004 to April 2005 exhibited climatic gradients that the total CO_2 uptake and ET increased with the mean temperature.

Fig. 1. Location of four study sites

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

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MEASUREMENT AND SIMULATION ON CARBON AND WATER FLUX OF THE CROPLAND ECOSYSTEM IN NORTH CHINA PLAIN

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North China Plain is one of the most important areas of food production in China. Measurement and simulation on its carbon and water flux can help us understand the formation mechanism of crop yield, and evaluate the role of farmland in climate change.

In this study, the experiment was performed at Yucheng Comprehensive Experiment Station (36° 57′ N,116 ° 36′ E, 20m a.s.l.) in the North China Plain characterized by a semi-humid and monsoon climate. Mean annual precipitation, temperature and global solar radiation at the station over the past 30 years are 528mm, 13.1℃, and 5225 MJm^{-2} respectively. The soil of the area is mainly the moisture soil and the salinized moisture soil. The vegetation is a winter wheat and summer maize rotation field. Winter wheat is sown in early October and harvested in mid June while summer maize is sown with the residues of the winter wheat in mid June and harvested in late September. The terrain surrounding it is vegetated with large, flat areas of crop field, upwind fetch of the site extends more than 5 km for winds from all directions.

Continuous fluxes and meteorological measurements with the eddy covariance (EC) technique began on October 20, 2002. The EC system, mainly composed of a 3D sonic anemometer (model CSAT3, Campbell Sci., Logan, UT) and an open path, CO_2/H_2O analyzer (IRGA, Li-7500, Li-Cor Inc., Lincoln, Nebrasks, USA), could measure virtual fluctuations and averages of wind velocity, temperature, water and CO_2 concentrations. Two soil heat flux plates (model HFT-3, Campbell Scientific Inc.) were embedded in between-rows and between-plants to determine fluxes. A data logger (model CR5000, Campbell Sci., Logan, UT) connected with the system operated at 10 Hz and the fluxes were averaged for 30 min periods. Along with the fluxes measurements, standard meteorological data were collected including air pressure, photosynthetic active radiation, net radiation, precipitation, soil temperature, soil moisture etc. Routine irrigation and fertilization were employed to achieve a non-limiting condition throughout the growing season.

We obtained the temporal variation characteristics of CO_2 and H_2O flux of the farmland ecosystem with the observed data. On the other hand, according to the Synthetic Model of Photosynthesis-Transpiration based on Stomatal Behavior (SMPTSB) at leaf level developed by Yu et al. (2004), we scaled it up to ecosystem level by introducing soil respiration and aerodynamic resistance. The NEP, ET, and WUE of the cropland ecosystem in North China Plain were estimated with the model. With the measured data obtained by EC system, the simulation results were verified. The comparison showed that the simulated NEP, ET, and WUE were in good agreement with the measured values with relative high R^2 values. Therefore, we deduced that the model not only provide a tool for simulating carbon and water flux at ecosystem level but also for partitioning the ET measured by EC system into evaporation and transpiration.

P50

CO_2 FLUX OBSERVED OVER A RICE PADDY FIELD BY THE EDDY COVARIANCE METHOD AND ITS QUALITY CHECK

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Rice paddy field is one of the most popular cultivation patterns in East Asia under a monsoon climate. And it takes a great important role in carbon budget. Therefore, we have been observed CO_2 flux above rice paddy field using eddy covariance method since 1999 in Okayama, Japan. The objectives of this observation are evaluating Net Ecosystem Exchange of CO_2 (NEE) between atmosphere and rice paddy, and investigating between its seasonal variation or inter-annual variation and environmental factors.

To evaluate reliable NEE at rice paddy, we have to check the data quality and to exclude the inappropriate data for eddy covariance method. In recent years, many kind of quality control were proposed; for example, criterion of atmospheric turbulence condition using u_*, inspection of skewness and kurtosis which are higher moment terms using its threshold for testing of instationarity. But thresholds of these methods are depending on site or observation system, so they are not universal. Then, we can not apply automatically the threshold which is determined for certain condition to other condition. In this study, we determine the appropriate threshold for rice paddy field, and conduct quality control for the data in 2003 and 2004. Then we calculate the cumulative NEE using selected data with complement of the deficit data.

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BOWEN RATIO MEASUREMENTS OF ENERGY BUDGET COMPONENTS OVER VARIOUS ECOSYSTEMS IN MYMENSINGH, BANGLADESH

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Micrometeorological studies on exchange of energy and water vapor between soil/vegetation and the atmosphere is a new research filed in Bangladesh. Partitioning of net radiation (*Rn*) into latent heat flux (*lE*), sensible heat flux (*H*) and ground heat flux (*G*) over any ecosystem was not reported so far in Bangladesh. We therefore designed experiments to provide preliminary information on *lE*, *H* and *G* over various ecosystems. Such information might be helpful for the AsiaFlux community to design gas flux measurements in Bangladesh in future. To fulfill our aim, experiments were carried out over various ecosystems *viz*. irrigated rice field, harvested rice field, grassland and bare land at Bangladesh Agricultural University Farm, Mymensingh from October to December 2004 using Bowen Ratio Energy Balance (BREB) technique.

Subtropical climate prevails in the experimental area. It is characterized by heavy rainfall from April to September and by a little shower from October to March. Late precipitation in September or even in October helped to store sufficient soil moisture during the experimental period. Soil moisture content, except for the irrigated rice filed, ranged from 39 to 45%. During the experiment, plant height of rice was 92-95 cm and its leaf area index was 2.8-3.0, while the harvested rice field had only rice straw with 10-15 cm in height. The grassland was covered with 34 species of grasses having 5-10 cm height, and the bare land site was a cultivated open land having no plants. A pair of temperature-humidity sensors equipped with homemade aspirators as well as a naturally ventilated net radiometer and heat flux plates were used to measure energy budget components. The experimental period at each site included 3 to 8 clear days in a row. The data in those periods were used for the following analysis.

At all of the four sites, diurnal trends of *Rn*, *lE* and *G* followed the diurnal course of global radiation. However, *H* showed slightly positive values, 5-15 W m^{-2}, only around midday and was almost zero in other hours in the daytime. In the total energy balance of the daytime (from 0600 to 1800 hours), *lE* was dominant at all of the four sites, while *H* was minor. *lE/Rn* was 0.92 on average at the irrigated rice field, 0.82 at the harvested rice field, 0.84 at the grassland and 0.79 at the bare land. *H/Rn* was the largest at the bare land (0.04 on average) and even smaller in other three sites. *G/Rn* was greater than *H/Rn*, and ranged from 0.07 at the irrigated rice field to 0.15 at the bare land. In summary, surface energy balance in the study period was characterized by dominant *lE* and negligibly small *H* under sufficient soil moisture conditions, with small modification by vegetation.

P52

SENSIBLE HEAT, LATENT HEAT, AND CO_2 FLUXES ON THE LOESS PLATEAU IN CHINA DURING THE SEASON FROM SPRING TO SUMMER IN 2005

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The Loess plateau is located in the middle region of the Yellow river basin, China, and occupies 380,000 km^2, which corresponds to about 3.9 % of total area of China. In May 2004, an observation system for measuring the atmospheric boundary layer (ABL) was installed in the southern part of the plateau in order to measure seasonal and inter-annual variations of ABL as well as to investigate the water cycles in the Yellow river basin. This observation was carried out as a part of the project of Yellow River Study, which has been promoted by Research Institute for Humanity and Nature, Japan, with cooperation by Chinese Academy of Sciences (CAS), China.

Flux Radiation Observation System (FROS) was established at the field of Changwu Agro-Ecological Experimental Station on the Loess Plateau (35°2'N, 107°8'E), Institute of Soil and Water Conservation, CAS. The elevation of the site is 1206.5 m. The average annual precipitation is 578 mm and the annual average air temperature is 9.2°C. The main species of crops in this region are wheat, corns, and apples, and much area of this region is randomly occupied by these agricultural fields. Meteorological instruments of FROS were installed on the 30 m-height observation tower and on the 2 m-height pole. Ultrasonic anemometers (Gill, UK) and open-path CO_2/H_2O gas analyzers (LI-7500, Li-COR, USA) were installed at heights of 30, 10, and 2 m. Wheat was seeded around the tower in early spring in 2005. Its height reached about 70 cm in May. The field of apple trees was situated in the north to northeast region. In the east, about 50 m apart from the tower, there are some residential buildings. Some narrow streets distribute around the observation site and residential houses stand alongside of the streets. Also, the main street lies at several hundreds meters apart from the observation site.

This study shows sensible heat, latent heat, and CO_2 fluxes observed by FROS during the season from spring to summer in 2005. The period of the analyzed data is from 11th May to 12th July. The main results are as follows. 1) In May, each flux had almost constant profile in the vertical direction, respectively. This indicates that the biological activities of plants were closely similar among the different footprint areas for each flux measured at different heights, in spite of presence of several species of plants around the observation site. 2) An apparent influence of water vapor deficit was observed, i.e. the extent of aperture of stomata might be significantly regulated by water vapor deficit. 3) In June, as the color of wheat turned to yellow gradually indicating its biological activity decreased, the amplitudes of latent heat and CO_2 fluxes measured at a height of 2 m became smaller than those measured at the other heights, 30 and 10 m. This may indicate that phenological degradation of wheat around the tower could be detected by the sensor at a height of 2 m. 3) In evening, efflux of CO_2 was observed frequently caused by that respiration overcame photosynthesis. However, the efflux did not continue any longer than several hours, which might be caused by that respiration decreased with temperature decreased. On the other hand, when evaporation occurred due to downward (negative) sensible heat flux in windy condition during nighttime, respiration was maintained throughout the night.

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CO_2 FLUX MEASUREMENT OVER WINTER BARLEY AND SOYBEAN FIELDS GROWING ON THE RICE BASED DOUBLE CROPPING PADDIES IN NORTHERN KYUSHU, JAPAN

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We conducted the CO_2 flux measurement for the agricultural field in northern Kyushu, Japan. In this area the rice based double cropping paddies are used to culture the winter barley from winter to next spring. The double cropping field has two chances to absorb the atmospheric carbons in a year. Additionally, occasional soybean culture on the converted upland from paddies has been widely introduced in summer seasons. The increase in soybean harvest yields on such fields is assumed to be lead by nitrogen cycle, suitable supply of nitrate to plant from decomposing stubbles in soil, accompanied characteristics in carbon cycle also is expected. However after barley remains are burned before the conversion to the rice paddy customary, it should be possible to reduce the greenhouse gasses from agriculture land. This observation aim to provide the characteristics of CO_2 fluxes under rice based double-cropping paddies as the basal study.

The study area is extensive reclaimed farmland (33o9'18"N, 130o18'30"E, 2 m ASL); mainly cropping rice paddies in summer and converted to grow malt barley in winter, occasionally used for soybean in summer. The observation was conducted from January 30 to May 19 for barley, from July 24 to November 12 in 2004 for soybean, March 9 to May 1 in 2005 for barley. At the top of the 3 m high observation mast, built at the center of the study area, the sonic anemometer (Model 81000, Young) and IRGA (Li-7500, Licor) were installed. The flux measurements of CO_2, sensible and latent heats, and momentum performed by eddy correlation method are automatically calculated by data logger (CR23X, Campbell) and recorded every 30 min.

The lack data caused by the uncertainty of the measurement are filled with the estimation from air temperature and solar radiations observed simultaneously. Seasonal variation of CO_2 flux (NEE) over the barley gradually increased with plant growth and approached to around –2.0 $mgCO_2/m^2/s$ in 120 days after seeding, and decrease to –0.5 $mgCO_2/m^2/s$ before harvest. During the growing, and they changes with LAI (leaf area index). The accumulated NEE was 437 $g\text{-}C/m^2$ in Apr. 23. The carbons taken out of the field as harvest yields was 121 $g\text{-}C/m^2$, and the stubbles and plant remains are plowed into the soil. The following soybean grow, variation of CO_2 flux approached to around –1.2 $mgCO_2/m^2/s$ (maximum in the daytime) in 35 days after seeding, and dropped to almost -0.0 $mgCO_2/m^2/s$ before harvest. The accumulated NEE in soybean was 251 $g\text{-}C/m^2$ in Nov. 12, and taken out carbon weight was around 68 $g\text{-}C/m^2$ estimated from harvest yields, which is quite smaller than normal. Considering the emission during uncultured period, the total NEE in this field (barley - soybean) was estimated around 150 - 200 $g\text{-}C/m^2/yr$ except compost application.

P54

Air Temperature Measurement Errors in a Naturally Ventilated Multi-Plate Radiation Shield

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In observational networks of air temperature, mechanically aspirated radiation shields are often replaced by naturally ventilated radiation shields because of the operational costs and power requirements. The radiatively-induced errors (radiative errors hereafter) need to be assessed for correctly interpreting air temperature data collected in a naturally ventilated shield. If sensor-shield systems within a network of air temperature measurements experience different radiative forcing, e.g. due to variable cloudiness or exposure differences, the horizontal temperature gradient may be incorrectly estimated. In addition, when air temperature measurements are used to evaluate the sensible heat flux from the surface with the bulk-transfer method, the radiative error could cause significant errors in the predicted sensible heat flux and even the wrong sign (Anderson and Baumgartner, 1998). As a multi-plate shield relies on the ambient wind for ventilation, radiative errors tend to occur when radiative forcing on the radiation shield is large and the ambient wind speed is low. Radiative errors need to be considered in correctly interpreting air temperature data collected in a multi-plate shield.

A series of field experiments are conducted to investigate the sources of the radiative errors of a commonly-used system consisting of the HOBO Pro Data Logger external thermistor (Model H08-031-08, Manufacturer: Onset Computer Corporation; Whiteman et al., 2000) enclosed in the Davis Instruments multi-plate shield (a.k.a. Onset Computer RS1). The amount of solar radiation reaching inside the shield is positively correlated with the ground surface albedo. The deviation of the shield surface temperature from the ambient air temperature generally becomes positive during the daytime and negative at nighttime. The magnitude of the systematic radiative error within the thermistor-shield system is assessed by comparing it with a RTD sensor in a mechanically aspirated shield. Empirical models are developed for correcting temperature errors using information on wind speed and net or solar radiation. The same empirical models may be applicable for systems consisting of different sensors and multi-plate shields by empirically determining new coefficients in the models.

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