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Contents

Report on the AsiaFlux Workshop 2006

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With more than 140 participants from 13 countries and regions, the AsiaFlux Workshop 2006 was held successfully from 29th November to 1st December 2006 in Chiang Mai, Thailand. This workshop was entitled "International Workshop on Flux Estimation over Diverse Terrestrial Ecosystems in Asia" and organized by AsiaFlux Steering Committee and Chiang Mai University (CMU, Thailand) with the funding supports from Asia-Pacific Network for Global Change Research (APN) and Ministry of Education, Culture, Sports, Sciences and Technology (MEXT, Japan). In addition, two Japanese research institutions, Forestry and Forest Products Research Institute (FFPRI, Japan) and National Institute for Environmental Studies (NIES, Japan), also supported this workshop. Participants come from various countries and regions inside and outside Asia, including Australia, Bangladesh, China, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, UK and USA.

This 5th meeting was the very first AsiaFlux workshop in tropical region, therefore the special session was entitled "Tropical Ecosystem" and we discussed much about the material cycle in the tropical region. Other topics included tower flux measurement and inter-comparison, biochemical processes, modeling, remote sensing and others in relation

Group Photo

to terrestrial material cycle.

The workshop opened with the welcome address and report by P. Angkasith (President of CMU, Thailand) and opening speech by Pungbun Na Ayudhya (Permanent Secretary, Ministry of Natural Resources and Environment, Thailand).

Y. Ohtani (FFPRI) and AsiaFlux sub-workgroups had reported the recent activities of AsiaFlux in the oral and poster sessions. The new AsiaFlux webpage would be available shortly and it would provide the latest information in the member's area. AsiaFlux database was constructed to promote synthesis analysis and interdisciplinary studies, and it would be accessible from the AsiaFlux webpage within the next few months. M. Falk (University of California, Davis, USA), G. Matteucci (Institute for Mediterranean Agriculture and Forest System, Italy) and R. Leuning (CSIRO, Australia) presented recent situations in global and regional networks in flux measurement. FLUXNET highlighted the importance of synthesizing the findings and announced that they were going to hold FLUXNET data synthesis workshop in February 2007.

Some of noteworthy presentations at this workshop were about new national/regional networks in flux observation in Asia. N. Tangtham (Kasetsart University, Thailand) reported about flux observations during past four decades in Thailand and the attempt of establishing a network "ThaiFlux" which consists of existing flux sites in Thailand. He also mentioned that the network has aimed to promote an information exchange and strengthen the collaboration among researchers in Thailand and it is hopeful that this activity will be strengthened and spread throughout Thailand based on this workshop. Y. Hsia (National Dong Hwa University, Taiwan) mentioned about Taiwan flux network, and several new approaches for flux measurements were reported by other Taiwanese researchers. The establishment plan of Philippine flux network was also introduced by M. Aguilos (Department of Environment and Natural Resources, Philippines). We would like to point out that many of broachers for those new network establishments (or the plans) were participants in AsiaFlux Training Course 2006, which was the most fruitful AsiaFlux activities in 2006. This course seemed to have a positive effect on the capacity building in Asia.

Oral Session

A day's field trip was made on the last day of the workshop. N. Tangtham and M. Suzuki (The University of Tokyo, Japan) kindly presented the flux site at the Huay Kog Ma Watershed Research Station, which has been jointly operated by Kasetsart University and The University of Tokyo. The Royal Flora Expo "Ratchapruek 2006" was also visited.

The numbers of presentations were 38 and 86 in oral and poster sessions respectively; this AsiaFlux Workshop 2006 was the largest of all AsiaFlux Workshops ever held since the establishment of AsiaFlux. AsiaFlux Workshop Management Sub-Workgroup (leader: Y. Fujinuma, workshop@asiaflux.net) is now discussing the detail of next annual workshop in 2007, so please wait for the first announcement!!

Acknowledgement

We would like to express our special thanks to all persons concerned, in particular to Masakazu SUZUKI whom provided an excellent field trip at Huay Kog Ma site and CMU staff, J. Saokad, P. Boonmee, P. Maniwara, K. Khanthong, K. Fongsa, S. Pakaew, P. Sae-Lee, B. Risana, P. Kaewduang and D. Pintana, whom always assisted us effectively during the workshop.

Special Issue on the Carbon Exchange Research in ChinaFLUX

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The Chinese Terrestrial Ecosystem Flux Research Network (ChinaFLUX) is a long-term national network of micrometeorological flux measurement sites that measure the net exchange of carbon dioxide, water vapor, and energy between the biosphere and atmosphere. It relies on the existing Chinese Ecosystem Research Network (CERN), fills an important regional gap and increases the number of ecosystem types in FLUXNET. The ChinaFLUX has been supported and financed by the Chinese Academy of Sciences and the Ministry of Science and Technology through grants KZCX1-SW-01-01 and 2002CB412501, respectively.

The ChinaFLUX network includes eight observation sites and encompasses a large range of latitudes (21º 57' N to 44º 30' N), altitudes, climates and species. The three grassland sites (HB, NMG and DX), located in the northwestern part of China along the Temperate-Alpine Rangeland Transect (China Grassland Transect, CGT), which spans from the Daxinganling Mountain Range in the northeast to the Qinghai-Tibet Plateau in the southwest, cover an altitudinal range from 1200 m to 4300 m. The four forest sites (CBS, QYZ, DHS, and XSBN) are influenced by monsoon climate to varying degrees. The DHS, QYZ, and CBS forest sites are distributed along the North-South Transect of Eastern China (NSTEC, the Fifteen Transect of Global Change and Terrestrial Ecosystems, GCTE), while the NMG and CBS sites are along the North East Chinese Transect (NECT, the Fifth Transect of GCTE). A crop site (YC) in the Northern China Plains, where annual rotation of wheat and maize is the dominant farming practice, was also equipped with the eddy covariance instrumentation.

All the above sites and transects are critical in regulating global climate change on the Euroasia continent. The selection of these micrometeorological sites is a tradeoff between micrometeorological criteria and the above-mentioned ecological considerations. Early results from ChinaFLUX were presented at an International Workshop on Flux Observation Research in Asia held from 1-3 December 2003 in Beijing, and a selected subset of these papers are presented into the special issue of *Agricultural and Forest Meteorology* (Volume 137, Issues 3-4, 2006). This special issue begins with an overview of ChinaFLUX and an evaluation of eddy covariance measurements at various sites (Yu *et al*., 2006). This is followed by papers showing seasonal variation and annual carbon balance in forest ecosystems in China (Guan *et al*., 2006 and Zhang JH *et al*., 2006), and several investigations of biotic and abiotic effects on ecosystem processes of carbon dioxide exchange (Wen *et al*., 2006; Zhang LM *et al*., 2006; Shi *et al*., 2006 and Fu *et al*. 2006). An exploratory study on the importance of low-frequency contributions to eddy fluxes is presented (Sun *et al*., 2006), while Wang *et al*. (2006) describe a canopy photosynthesis and transpiration coupled model. Long-term measurement of the net exchange of CO_2, H_2O and energy fluxes between vegetation and the atmosphere have great potential to exhibit the role of Chinese terrestrial ecosystem in the global carbon and water cycles and improve our understanding of its environmental driving mechanism based on the ChinaFLUX sites along three major terrestrial transects in China (CGT, NSTEC and NECT).

Herein, we would like to express our appreciation to the participants of the workshop for presenting their ideas and research results that ultimately lead to this special issue, and to the authors, reviewers and guest editors involved. It has been our pleasure to provide an opportunity for Chinese scientists to showcase our work to an international audience. Of course, much progress in flux observation research has been made in ChinaFLUX over the two years since the workshop, with most results published in two special issues of Science in China Series D - Earth Science in

2005 and 2006. We hope these papers will provide a linkage between scientists of ChinaFLUX with the international community to quantify and improve the understanding of the controls on carbon balances in global terrestrial ecosystems. If you felt interested in our special issues or others, please visit the ChinaFLUX website: www.chinaflux.org or contact me: wenxf@igsnrr.ac.cn.

Validation of Terrestrial Carbon Cycle Model with AsiaFlux Data

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1. Introduction

Accurate evaluation of regional carbon budget is required to understand the nature of global carbon cycle and predict and manage the climate change in the future. In fact, many tower flux sites have been established in the Asia region for the purpose: i.e., AsiaFlux. It is generally recognized that scaling-up of the site-level data to region carbon budget requires intimate linkage with remote sensing and/or modeling approaches.

A comprehensive project of regional carbon budget, "Integrated Study for Terrestrial Carbon Management of Asia in the 21st Century Based on Scientific Advancements" supported by the Global Environmental Research Fund of the Japan Ministry of the Environment (GERF-S1), is conducted from April 2002 to March 2007 for the purpose mentioned above. The project consists of sub-themes such as filed observation and synthesis (bottom-up), atmospheric observation and model inversion (top-down), ground and satellite remote sensing, ecosystem modeling, and socio-economic interpretation. It is intended that most plausible regional carbon budget in East Asia would be obtained through collaborations of different approaches.

This article shows an example of linkage between flux observation and modeling conducted in the GERF-S1 project: that is, validation of terrestrial carbon cycle model using flux measurement data from several AsiaFlux sites. Validation of ecosystem models, especially using 'independent' data, has been a difficult problem, leading to large uncertainties in model results. Recently, increasing amount of data from continuous flux measurements allow us, gradually, to confirm model performance, although there remain deficiencies in observational data. Below, I provide a brief description of a terrestrial carbon cycle model used in the GERF-S1 project and show preliminary results of model validation using data from AsiaFlux sites.

2. Simulation with terrestrial carbon cycle model

2.1. Model description

A process-based terrestrial carbon cycle model was developed to simulate and analyze observed CO_2 flux data. The model was derived from a simple ecosystem model Sim-CYCLE (Ito and Oikawa 2002), but has revised to have higher complexity of model structure and more accurate parameterization of specific processes. The revised model (Ito 2005; Ito *et al*. 2005, 2006, 2007) is composed of four sectors: tall trees constituting canopy, shrubs and grasses covering forest floor, litter or dead biomass, and humus or organic matter in mineral soil (Fig. 1). Each sector is sub-divided into several functional compartments; for example, tall tree sector is divided into three compartments representing leaf (assimilative organ), branch and stem (aboveground non-assimilative), and root (belowground non-assimilative), respectively. Therefore, biomass, leaf area index (LAI), and soil organic carbon are prognostic variables of the model. Net ecosystem carbon budget, termed net ecosystem production (NEP), is determined as the difference between gross primary photosynthetic production (GPP) and ecosystem respiration (ER), which is composed of plant autotrophic respiration (AR) and soil microbial heterotrophic respiration (HR). Each of the CO_2 fluxes is parameterized in ecophysiological manner, so that carbon budget responses to environmental change are appropriately included. Within an ecosystem,

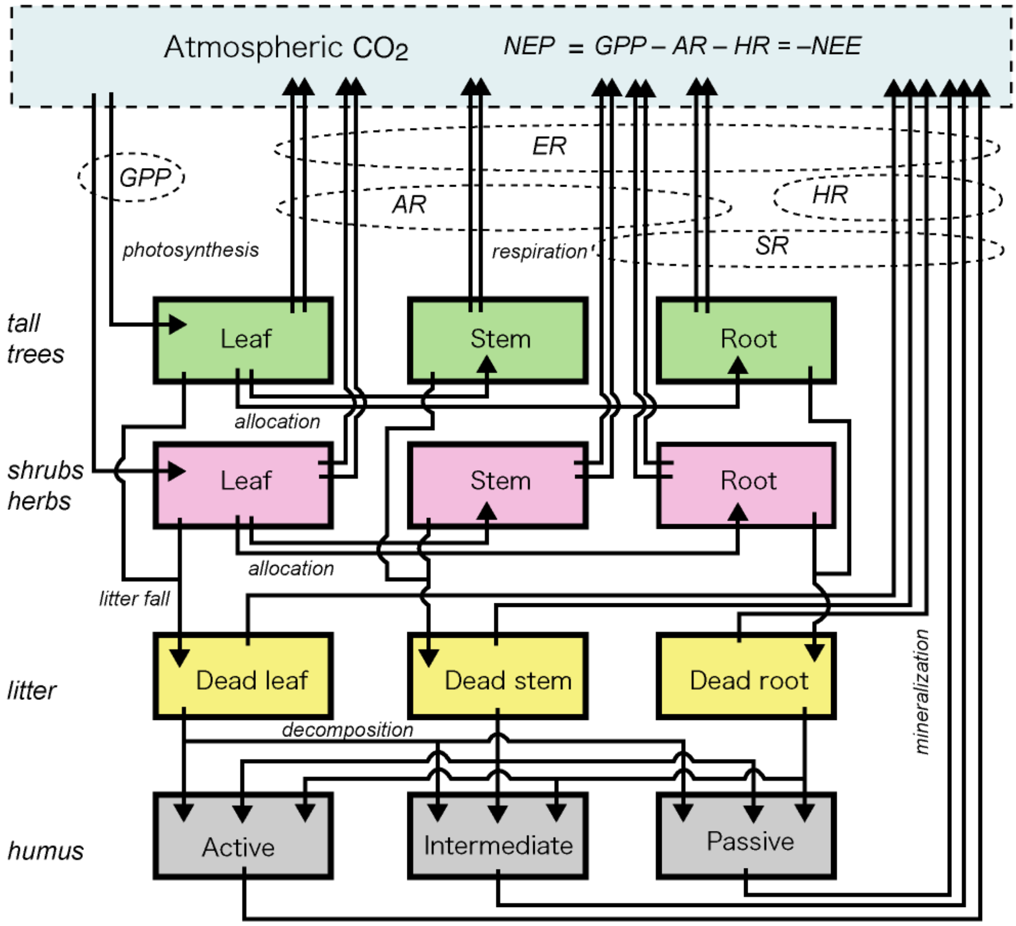

Figure 1. Schematic diagram of terrestrial carbon cycle model.

carbon assimilated from the atmosphere is allocated to plant compartments, abandoned as dead biomass, and decomposed and mineralized in the soil compartments. Most of the carbon fluxes are calculated at daily time step, enabling us to simulate intra-seasonal to decadal variations. Additionally, the model can calculate GPP, AR, and litter HR at 30-min time step to capture diurnal variations such as daytime-nighttime contrast and solar radiation fluctuations. Effects of disturbances (e.g. logging and wildfire) are, if necessary, simulated by removing carbon stocks and producing debris.

2.2. Regional datasets and simulation

The terrestrial carbon cycle model was used to simulate carbon budget in East Asia region. First, the model applicability was confirmed at a cool-temperate deciduous broad-leaved forest in Takayama site, central Japan. Using forest and soil survey data (see Ito *et al*. 2005 for details), model parameters were calibrated for the biome type of deciduous broad-leaved forest. The simulated daily NEP using tower-observed meteorological data was compared with observed net ecosystem CO_2 exchange (NEE by Saigusa *et al*. 2005). Note that this comparison is not a truly independent validation, because field data were used for parameter calibration beforehand. Second, a regional simulation was performed using broad-scale datasets of topography, land cover, meteorology, and soil conditions. The simulation covers the East Asia region ranging from 30° to 50°N and from 125° to 150°E with a fine spatial resolution as high as approximately 1km. Using the NCEP/NCAR reanalysis data from 1948 to 2005, daily carbon

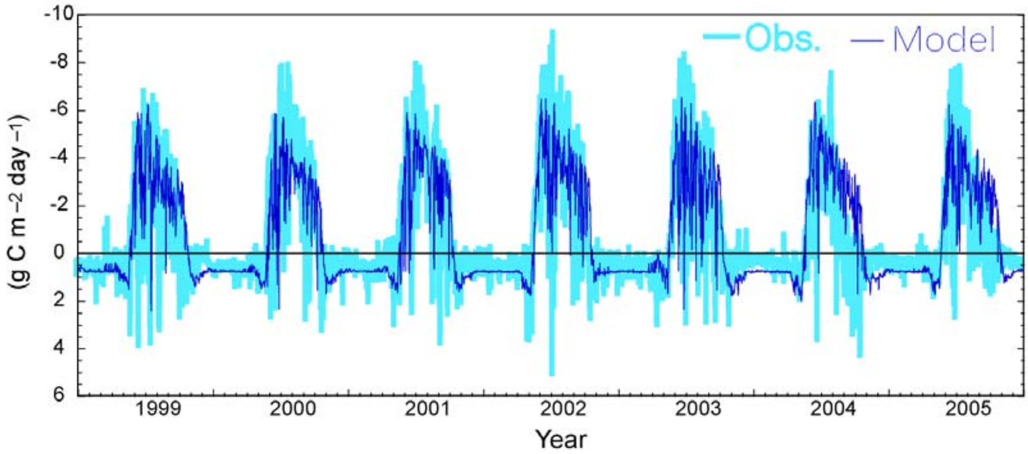

Figure 2. Comparison of net ecosystem exchange (i.e. negative for ecosystem uptake) at Takayama site between the model simulation and flux observation. Note that model parameters were calibrated beforehand.

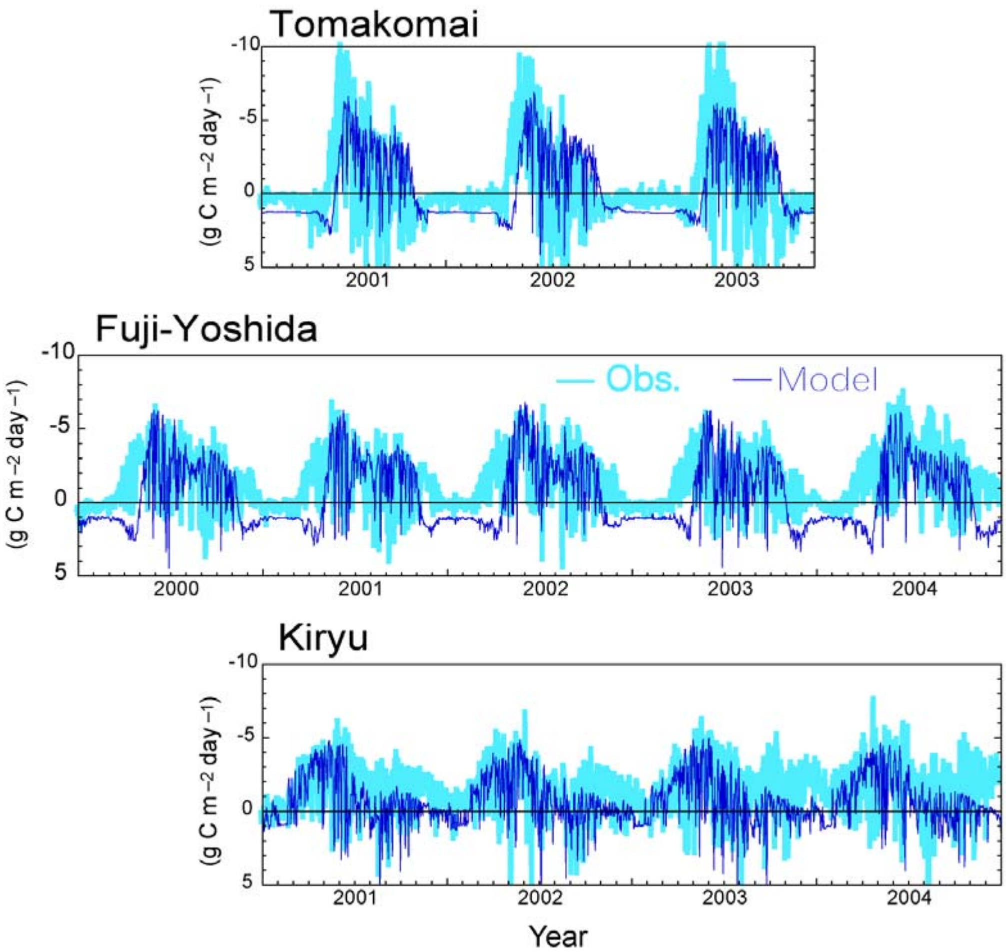

Figure 3. Comparison of net ecosystem exchange at three AsiaFlux sites: (upper) Tomakomai, (middle) Fuji-Yoshida, and (bottom) Kiryu. The daily gap-filled flux data were obtained from GERF-S1 data-sharing web site.

budget mapping in East Asia was accomplished. Subsequently, calculated results were extracted for grids including several (AsiaFlux) sites in Japan: an artificial boreal deciduous coniferous forest in Tomakomai, a temperate evergreen coniferous forest in Fuji-Yoshida, and a warm temperate mixed forest in Kiryu. The daily gap-filled net ecosystem exchange (NEE) data were obtained from the GERF-S1 data-sharing web site. Note that this is an independent validation for the model simulation, because no attempt has been made to calibrate model parameters for improving agreement with field measurements.

3. Results at AsiaFlux sites

At Takayama site, where model parameters were calibrated beforehand, the model simulation shows a good agreement with the flux measurement during the period from 1999 to 2005 (Fig. 2). The seasonal variation of deciduous forest was evident, such that a clear shift from source to sink in late spring accompanied with leaf display was appropriately retrieved. Although day-by-day variation in the simulated NEE seems slightly small during the growing period, leading to lower summer peaks, mean annual carbon uptake (about 200 $gC \cdot m^{-2} \cdot year^{-1}$) was comparable with that observed at the site. Here, it is noted that the net carbon sink in the model simulation was largely attributable to a disturbance impact about 50 years ago (Ito *et al*. 2005). Although the agreement was obtained as a result of calibration, the model allowed us to analyze the current carbon dynamics in this site with a high quantitative credibility and integrity.

In the independent validation, the model simulation shows still fair agreement with the flux observation at AsiaFlux sites, even though no site-specific data was referred (Fig. 3). For example, difference in seasonal NEE change among different forest types in the northern temperate zone was properly captured. However, the model simulation was inconsistent in several features. For example, in Tomakomai site, spring NEE shift in the model simulation was later than the observation, implying a problem in leaf phonological scheme in the model. On the other hand, in Fuji-Yoshida site, seasonal variability in the simulated NEE was represented too strongly, although its amplitude was comparable. This disagreement was largely attributable to inconsistency in land cover classification; the land-cover data used in the regional simulation

4. Concluding remarks: carbon budget in East Asia

Validation is an indispensable procedure for reliable model simulations; in other words, insufficient validation due to data deficit can bring about substantial uncertainties, especially at ecosystem and larger scales. The increasing amount of flux measurement data (e.g. FLUXNET and AsiaFlux data) allows us to perform more straightforward and robust validation of ecosystem models. In the GERF-S1 project, the regional model, which was partly validated using flux data, was used to estimate the carbon budget in East Asia. However, obviously, further researches are required for the following aspects. (1) The coverage of validation sites is still insufficient to capture the heterogeneity at regional scale. (2) Technical and systematic biases can remain in observations (e.g. nighttime flux and topographic effect), and therefore an agreement with the current data would not guarantee accuracy but plausibility of a simulation.

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Carbon Budgets of the Terrestrial Ecosystems in China: A Five-year Synthesis

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It has been well recognized that carbon cycle in terrestrial and ocean ecosystems plays an important role in climate change. To evaluate the carbon budget in terrestrial and marginal sea ecosystems of China, a flagship project entitled Study on Carbon Budget in Terrestrial and Marginal Sea Ecosystems of China (CBTSEC) was launched by the Chinese Academy of Sciences (CAS) in 2001. Around 150 scientists and more than 250 graduate and postdoctoral students from 18 CAS institutes with different academic disciplines are involved in the project.

Over the last five years, the Chinese scientists have been working on the scientific themes including the geographical and temporal patterns of carbon sources and sinks, the driving processes and control mechanisms of carbon cycling in terrestrial ecosystems, the likely future dynamics of the carbon budgets, and options that can enhance carbon storage and/or reduce carbon emissions from these ecosystems (Fig. 1).

1. Net ecosystem exchange: Observations

1.1 ChinaFLUX

The Chinese Terrestrial Ecosystem Flux Research Network (ChinaFLUX, www.chinaflux.org) was built in 2002 to monitor exchanges of energy, carbon and water between the land and atmosphere. The flux stations in ChinaFLUX are distributed in enormous diversity of ecosystems, ranging from temperate broad and needle leafed forests in the northeastern, to tropical forests in the southern China, wheat-maize cropping system in the northern China Plain to steppe and shrub vegetation in Tibet (Fig. 2). Eddy fluxes are measured with eddy covariance systems consisting of an open-path CO_2/H_2O gas analyzer and a 3-D sonic anemometer/thermometer. A data logger records the eddy covariance signals at 10 Hz for archiving and on-line computation of the turbulence statistics. Soil respiration measurements are made by a static chamber/gas chromatographic system at both the eddy flux sites and the chamber-only sites. A general description of the flux stations in ChinaFLUX can be found in Yu et al. (2006a).

1.2 Observed net ecosystem production

A primary analysis of the carbon fluxes from ChinaFLUX indicated that the temperate broad and needle leaved forests (CBS) in the northeastern, the subtropical planted forest (QYZ) in the eastern, the tropical evergreen broad-leaved forest (DHS) in the southern and wheat-maize cropping system (YC) in the northern China generally act as the carbon sink (198 to 499 $gC{\cdot}m^{-2}{\cdot}yr^{-1}$) although interannual variations are significant (Table 1). A weak

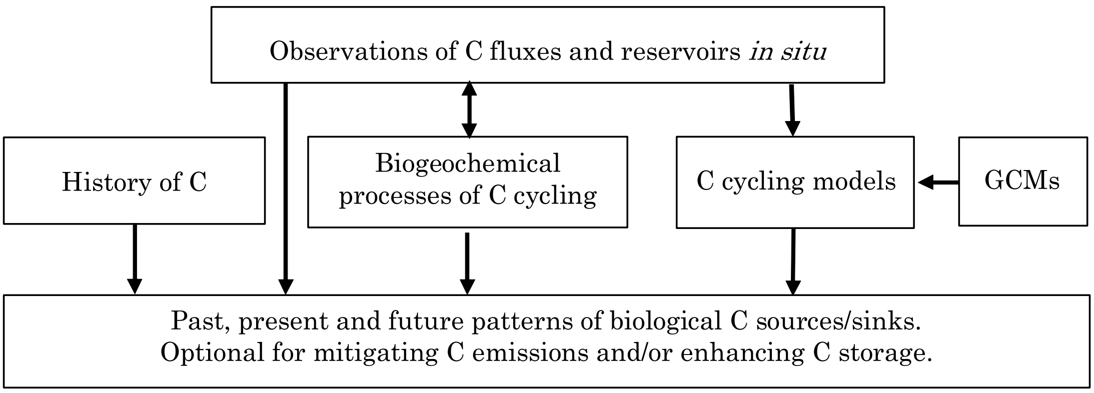

Fig. 1 CBTSEC framework

Fig. 2 Distribution of eddy covariance and static chamber observation sites in ChinaFLUX

Table 1 A summary of air temperature, annual precipitation and net ecosystem production in different terrestrial ecosystems from 2003 to 2005 (Source: Yu *et al*., 2006b)

Site	Year	Annual mean T (°C)	Annual Precipitation (mm)	NEP ($gC·m^{-2}·yr^{-1}$)
CBS	2003	4.7	774	242
	2004	4.9	707	257
	2005	3.4	690	279
QYZ	2003	18.9	945	387
	2004	18.6	1485	424
	2005	18.0	1330	316
DHS	2003	20.7	1289	436
	2004	20.5	1298	499
	2005	20.2	1424	368
YC	2003	12.6	675	198
	2004	13.4	861	318
HB	2003[a)]	-1.4	531	63
	2004[a)]	-1.9	494	85
	2005[a)]	-1.3	542	52
	2003[b)]	-1.4	531	-68
	2004[b)]	-1.8	494	-71
	2005[b)]	-1.1	542	-105
NMG	2004	1.7	364	-110
	2005	1.0	144	-139
DX	2004	1.7	550	-16
	2005	2.4	490	-39

a) *Potentilla fruticisa* shrub; b) *Kobresia tibetica* swamp meadow

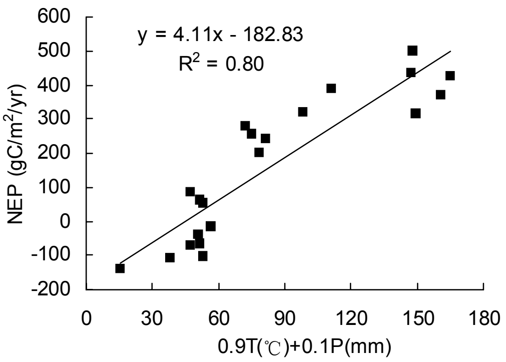

Fig. 3 Correlation of NEP with a combination of annual precipitation (P) and annual mean temperature (T)

carbon sink (52 to 85 gC·m^{-2}·yr^{-1}) was observed in the frigid shrub (HB), but a weak carbon source (-68 to -105 gC·m^{-2}·yr^{-1}) occurred in the frigid swamp (HB) in the northern Qinghai–Tibetan Plateau (Table 1). A two-year observation suggested that the typical steppe and meadow steppe in Inner Mongolia (NMG) released carbon with an average of -125 gC·m^{-2}·yr^{-1} and the typical *Kobresia* meadows in the northern Tibetan Plateau (DX) released a small amount of approximately -27 gC·m^{-2}·yr^{-1} (Table 1).

A further analysis of the datasets in Table 1 suggested that approximately 80% of the variability in annual NEP could be explained by a linear combination of temperature and precipitation (Fig. 3).

2. Carbon budgets during 1980-2000: Model simulation

2.1 Integrated model system

The integrated model system consists of four carbon models and a common database. The carbon models concerning weather variables, soil parameters, plant species and human activities (cropland) were developed for forest, grassland, cropland and wetland, respectively. These models were integrated within the GIS to infer complete space–time distributions of carbon budgets over the last two decades, and to predict the likely future dynamics of the carbon budgets. A common database including site-specific and up-scaled datasets was established to provide temporal and spatial information on climate, soil, land-use and land-cover for the integrated model. The up-scaled datasets have a spatial resolution of 10km×10km.

2.2 Carbon budgets from 1980 to 2000

Land-use and land-cover were identified by the remote sensing technique. Acreages of forest, grassland, cropland and wetland in mainland China are approximately 130.0, 395.3, 136.0 and 9.1 Mha, respectively.

The integrated model was run for each 10km×10km grid at a daily step from 1980 to 2000. Model outputs mainly include gross primary production (GPP), autotrophic respiration (Ra), net primary production (NPP), heterotrophic respiration (Rh), net ecosystem production (NEP) and soil organic carbon (SOC). Table 2 shows the model estimates of NPP, Rh and NEP in different ecosystems.

The simulated carbon sink in the forest and carbon source in the grassland on a national scale (Table 2) are generally lower than the observations from the ChinaFLUX (CBS, QYZ, DHS and NMG in Table 1), while the simulated and the observed NEP are comparable in the cropland (YC in Table 1).

The temporal changes of NPP, Rh and NEP in different terrestrial ecosystems are given in Fig. 4. Table 3 shows the total amount and annual average of NPP, Rh and NEP from 1980 to 2000.

Higher NPP in 2000 occurred in the eastern and southeastern regions and lower NPP appeared in the western, northeastern and northwestern regions (Fig. 5a). Crop NPP and forest NPP contributed greatly in the eastern regions and the southeastern regions.

Table 2 A summary of NPP, Rh and NEP in different terrestrial ecosystems from 1980 to 2000

Ecosystem	NPP (gCm^{-2}yr^{-1})			Rh (gCm^{-2}yr^{-1})			NEP (gCm^{-2}yr^{-1})		
	Average	Max.	Min.	Average	Max.	Min.	Average	Max.	Min.
Forest	807	961	668	634	769	428	172	239	55
Grassland	134	169	107	146	186	129	-12	4	-36
Cropland	545	601	453	263	304	205	282	310	240
Wetland	231	263	176	110	121	99	121	143	66

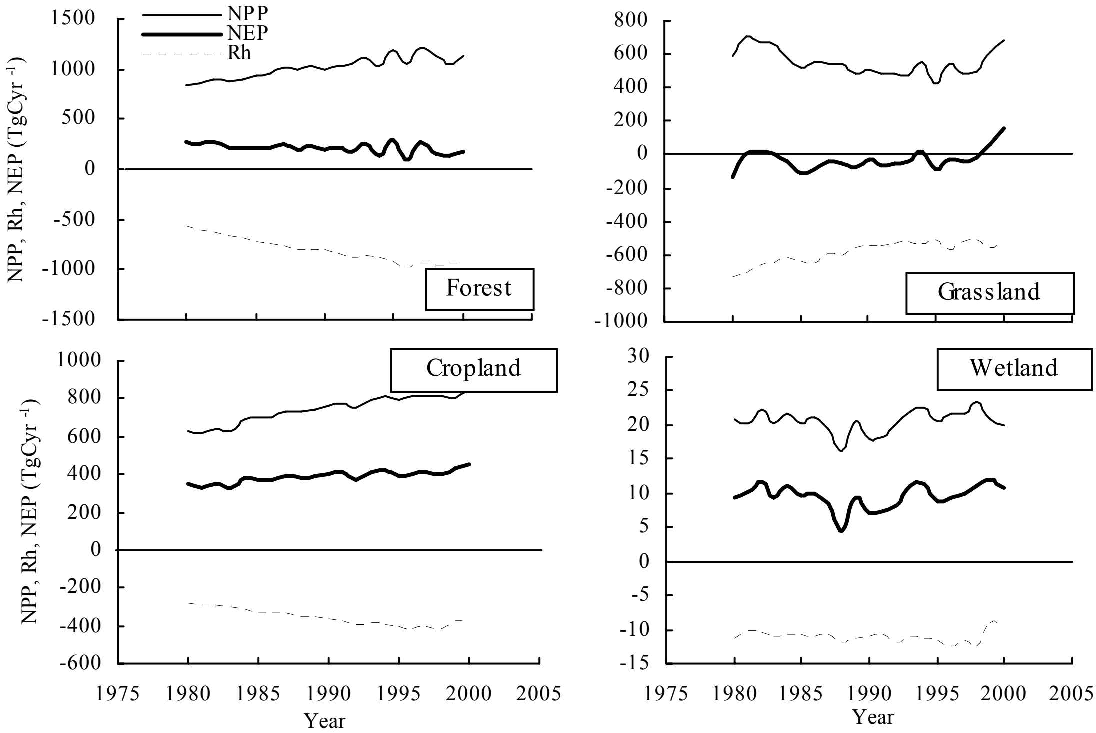

Fig. 4 Simulated changes of NPP, Rh and NEP from 1980 to 2000

Table 3 Simulated NPP, Rh and NEP in different terrestrial ecosystems from 1980 to 2000

Ecosystem	**NPP**		**Rh**		**NEP**	
	Total (Pg C)	Average (Tg Cyr^{-1})	Total (Pg C)	Average (Tg Cyr^{-1})	Total (Pg C)	Average (Tg Cyr^{-1})
Forest	21.26	1012	16.85	802	4.41	210
Grassland	11.59	552	12.25	583	-0.66	-31
Cropland	15.59	742	7.45	355	8.14/0.48[a)]	387/24 [a)]
Wetland	0.43	21	0.23	11	0.20	10
Total	48.87	2327	36.78	1751	12.09/4.43 [a)]	576/213 [a)]

a) Taken the changes in SOC instead of NEP on cropland into account

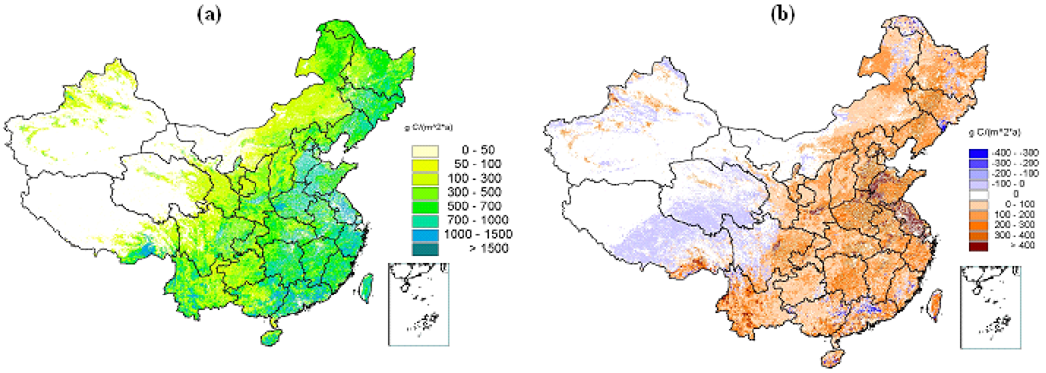

Fig. 5 Spatial distribution of simulated NPP (a) and NEP (b) in 2000

In contrast with the spatial distribution of NPP, carbon sink occurred in most of the regions in northeastern, northern, eastern, southwestern and southern China, while carbon source appeared in the regions of northwestern China and in parts of northeastern, southwestern and southern China (Fig. 5b).

An area-weighted annual NPP, Rh and NEPin 2000 were estimated to be 397.6, 277.0 and 120.6 C $m^{-2}yr^{-1}$, respectively.

2.3 Carbon sequestration in agricultural soils during 1980-2000

To quantitatively assess the changes of SOC in croplands over the last two decades, a total of 132 published papers since 1993 was compiled that report measurements of topsoil (0-20cm) organic carbon in different regions. The area covered by the sampling region is 59.6 Mha, accounting for approximately 44% of the total croplands in mainland China. The shortest period for comparison in the compiled database is 6 years and the longest is 24 years. The comparison periods of 6—10 years, 11—15 years, 16—20 years and 21—24 years account for 10%, 34%, 46% and 10% of the total, respectively.

A meta-analysis of the database indicated that the concentration of topsoil organic carbon increased in 53%—59%, decreased in 30%—31% and stabilized in 4%—6% of the national croplands, respectively. An overall increase in SOC storage ranged from 359 Tg to 463 Tg in topsoil (0-20 cm) and from 470 to 629 Tg in 0~40cm soil layer from 1980 to 2000. Model estimates suggested that the SOC increased in 71%—76%, decreased in 22%—25% and stabilized in 3%—4% of the national croplands, respectively. Great SOC sequestrations

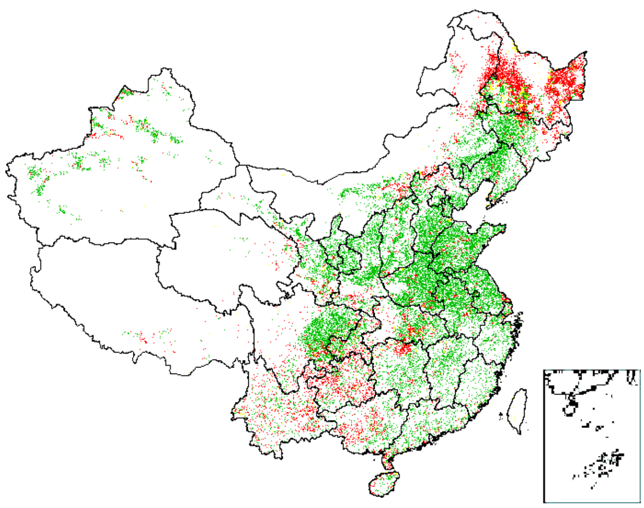

Fig. 6 Changes of SOC in croplands between 1980 and 2000
(Green and red colors represent increase and decrease in SOC, respectively)

Table 4 Comparison of model estimates and Meta-analysis of SOC change from 1980 to 2000

Changes in SOC	Model estimates	Meta-analysis
Area of SOC increased	71~76%	53~59%
Area of SOC decreased	22~25%	30~31%
Area of SOC balanced	3~4%	4~6%
C density (t·hm^{-2})	2.94~4.15	3.46~4.62
C storage (Tg)	402~562	470~629

occurred in the eastern, central and most regions of southern China, while C loss appeared in Heilongjiang Province and in partial regions of northeastern, southwestern and southern China (Fig. 6). An overall increase in SOC storage ranged from 402 Tg to 562 Tg during the same period, which is comparable to the meta-analysis (Table 4).

3. Carbon budgets from 2000 to 2050: Model prediction

3.1 Climate change scenario

FGOALS (Flexible Global Ocean-Atmosphere-Land System Model) developed by scientists in the Institute of Atmospheric Physics can be used to simulate the observed spatial distribution and annual cycles of temperature and precipitation for East Asia quite well and has been widely applied in the studies of climate variability, air-sea interaction and monsoon. The output of FGOALS under A1B scenario was adopted to drive the integrated carbon model.

The national averaged surface temperature projected by FGOALS would increase by 1.0°C over the period from 2000 to 2050 and the atmospheric CO_2 concentration will correspondingly reach 535 ppm by 2050 (Fig. 7). The increase in temperature would not be evenly distributed under the A1B scenario (Fig. 8). The most significant increase would occur in the regions of the Tibet Plateau and Xinjiang in western China with the values of 0.6~1.6°C till the late 2040s (Fig. 8). Regions in northern and northeastern China would also face significant temperature increase (0.4~0.6°C), while a slight decline would appear in southwestern China. The rest of the country including southern and eastern China would have a slight increase or remain constant (Fig. 8).

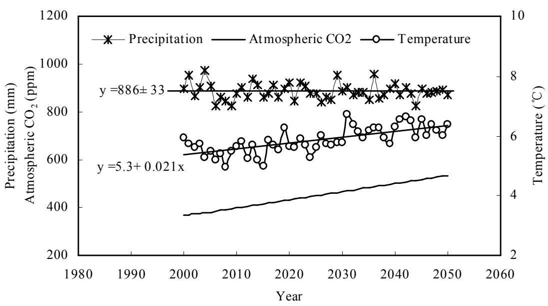

Fig. 7 Predicted changes in temperature, precipitation and atmospheric CO_2 concentration under the A1B scenario

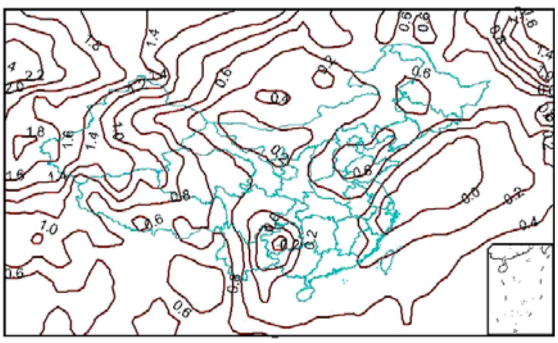

Fig. 8 Predicted changes in air temperature between the early 2000s and the late 2040s

3.2 Predicted carbon budgets under A1B scenario

Assuming that the land-use change in China would not happen from 2000 to 2050, carbon budgets in different terrestrial ecosystems were predicted under the A1B scenario. Figure 9 shows the temporal changes of NPP, Rh and NEP from 2000 to 2050. Figure 10 gives the spatial pattern of predicted NPP and NEP in 2050.

Table 5 gives the total amount and annual average of NPP, Rh and NEP. Compared with the carbon budgets from 1980 to 2000 (Table 3), climate change would promote NPP (Table 5). An overall increase in annual average would be approximately 20%. A significant increase would be in the forest (26%), but the increase in Rh would be also most significant (44%).

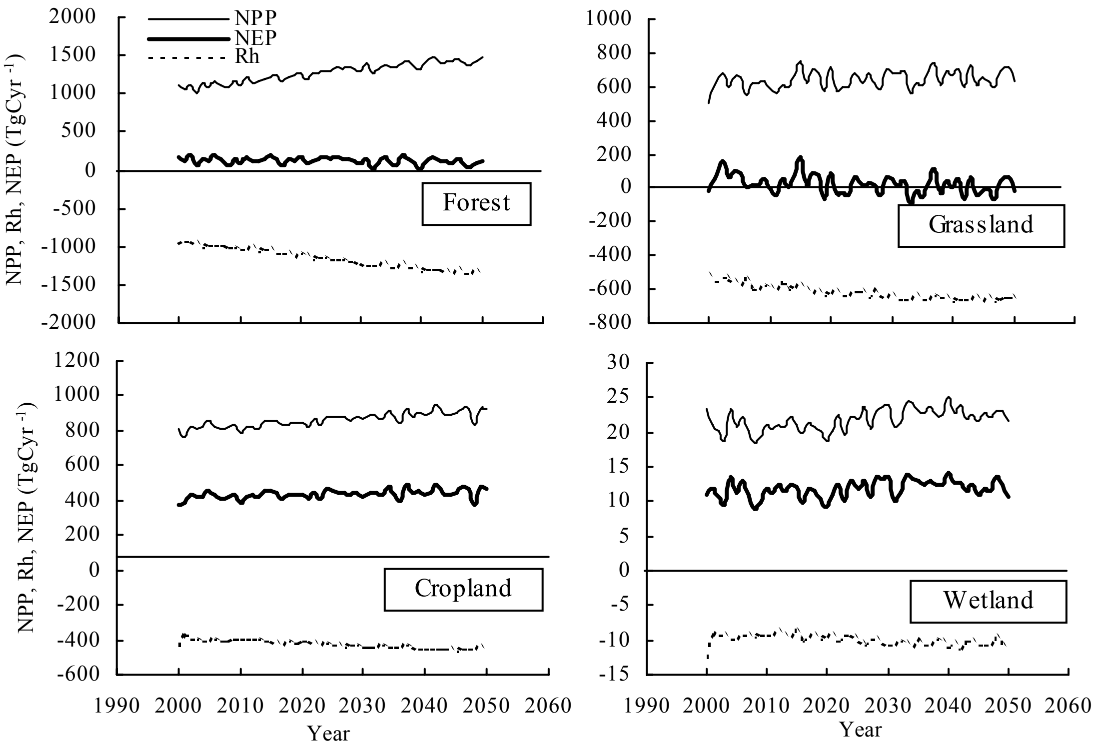

Fig. 9 Changes of predicted NPP, Rh and NEP from 2000 to 2050 under A1B scenario

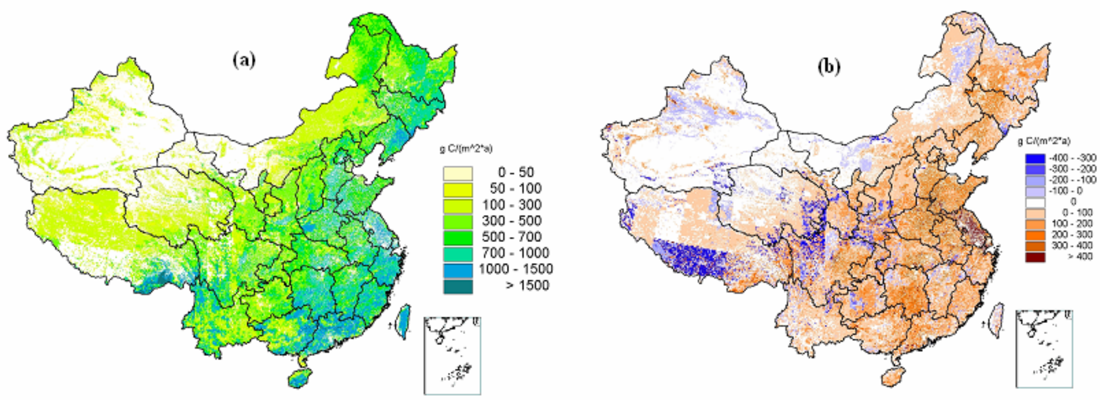

Fig. 10 Spatial distribution of predicted NPP (a) and NEP (b) in 2050 under A1B scenario

Table 5 Predicted NPP, Rh and NEP in different terrestrial ecosystems from 2000 to 2050 under A1B scenario

Ecosystem	NPP		Rh		NEP	
	Total (Pg C)	Average (Tg Cyr^{-1})	Total (Pg C)	Average (Tg Cyr^{-1})	Total (Pg C)	Average (Tg Cyr^{-1})
Forest	65.03	1275	58.84	1154	6.19	121
Grassland	32.69	641	31.50	618	1.19	23
Cropland	43.91	861	21.65	424	22.26/0.79 [a)]	437/16 [a)]
Wetland	1.11	22	0.51	10	0.60	12
Total	142.74	2799	112.50	2206	30.24/8.77 [a)]	593/172[a)]

a) Taken the changes in SOC instead of NEP on cropland into account

The annual average of NEP would not change significantly over the period from 2000 to 2050 (Table 5) in contrast with that from 1980 to 2000 (Table 3), but the carbon sink would reduce if take the changes in SOC instead of NEP on cropland into account (Table 5).

3.3 Predicted carbon budgets contributed by reforestation

China has launched several long-term reforestation projects and some of the projects have been put into practice since 1978 (http://www.forestry.gov.cn/SHTGC/index.asp). The projected area of reforestation under the projects of natural forest conservation, converting farmland to forest, and key shelter forest belt construction in "3-North" areas and the middle and lower reaches of Yangtze River Basin is 46.4 Mha up to 2010 and achieves 69.1 Mha till 2050 with the deduction of accomplished reforestation (Fig. 11).

Carbon budgets from the reforestation were predicted by running the integrated model under A1B scenario (Fig. 12). Model prediction suggested that an overall NEP from the reforestation would be 5.2Pg C with the deduction due to land-use change (e.g. reforestation in cropland) till 2050, approximately 0.1 Pg C per year.

4. Uncertainties and future requirements

4.1 Interannual variations and uncertainties

Significant interannual variations of NEP were observed in the ChinaFLUX sites (Table 1), suggesting that a short-term (e.g. 2-3 years) observation may be insufficient to obtain an accurate carbon exchange in the site-specific ecosystems. A long-term measurement is essential to explain the variations and to improve our understanding.

While estimating regional carbon budgets by integrating model with GIS, uncertainties of the model estimates in the present study might have been introduced. The potential sources of uncertainties may mainly come from the model performance, the model inputs (e.g. land-use

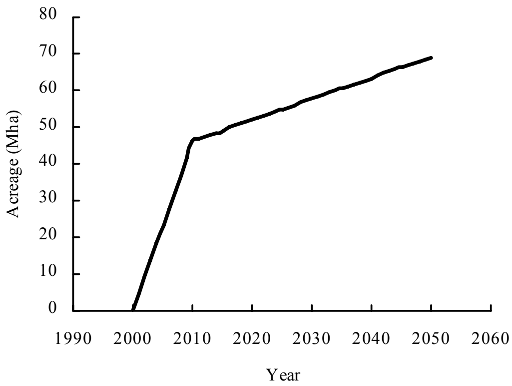

Fig. 11 Projected acreage of reforestation

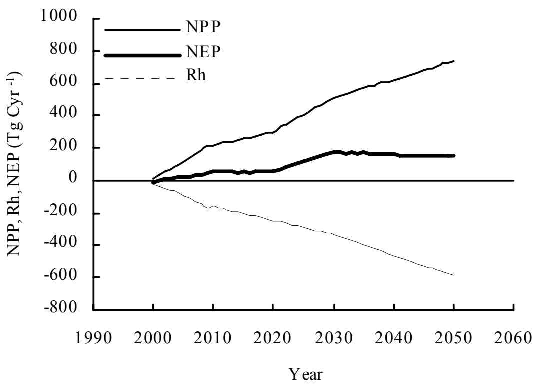

Fig. 12 Simulated changes of NPP, Rh and NEP

change from 1980 to 2000, up-scaled soil and climate parameters) and the climate change predictions adopted as the integrated model driver.

4.2 Future requirements

Future requirements to obtain reliable estimates of carbon budgets in terrestrial ecosystems of China include a further validation, modification and verification of existing models including those developed in this study and others used worldwide, the improvements of model inputs, the comparison of model outputs and the quantification of the uncertainties of model estimates.

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Topographical Effect on Soil Respiration in Mountainous Catchment

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1. INTRODUCTION

In recent years, the eddy correlation method for measuring CO_2 flux has been used increasingly to evaluate the carbon uptake capacity of forests (e.g., Yasuda *et al*., 2001; Nakai *et al*., 2003). This method, however, is generally used for forests growing on flat terrain. Evaluation of the carbon uptake by forests on topographically complex terrains typical of Japan requires measurements of tower CO_2 flux, and comparison of the values obtained by CO_2 flux measurements from both foliage and at the forest floor. For example, Kominami *et al*. (2003) compared the tower flux using the eddy correlation method and CO_2 efflux measured from foliage and at the forest floor using the chamber method, when wind speed is low and atmospheric stability is high. Their results indicated that the estimated flux in the former case was only 40% of the latter, which suggests that CO_2 gas migrated downward on inclined surfaces. The difference in results provided by the two methods for forests with major topographic variations was greater than the difference in a flatland forest reported by Goulden *et al*. (1996) and Lavigne at al. (1997).

In order to compare data on CO_2 flux at the forest floor with tower-flux data from above the forest canopy using the eddy correlation method, it is necessary to evaluate time series data on soil respiration rate and spatial variation at the scale of small watersheds in mountainous terrains. Time series data have been collected using automatic chambers by Mizoguchi *et al*. (2003) and Liang *et al*. (2003). Research on spatial variation within small watersheds in mountainous terrains has been limited. Jia *et al*. (2003) reported on spatial variation over 2 days (measurement conducted once each day), but this provides very little data with which to work. In general, very few time series studies have been conducted on topography-dependent spatial variation in the soil respiration rate.

This study focused on providing time series data on soil respiration rate, and on spatial variation in those data, by determining the relationships among soil respiration rate, soil temperature, and soil moisture content, based on multipoint year-round observations in a small mountain watershed. Soil temperature and soil moisture content can be monitored easily and nondestructively. Previous work in the Yamashiro Experimental Forest has included eddy correlation above the forest canopy (Kominami *et al*., 2003), CO_2 flux at foliage surfaces using an automatic opening/closing chamber (Miyama *et al*., 2003), CO_2 efflux at the forest floor (Tamai *et al*., 2005a), CO_2 efflux from coarse woody debris (Jomura *et al*., 2005), Net primary production based on the stem census (Goto *et al*., 2003) and root respiration (Dannoura *et al*., 2006). These studies demonstrated the feasibility of comparing time series data on soil respiration rate (taking into account spatial variation) with results using the eddy correlation method, or other methods. In this study, we used 360 soil collars (round, 9.1 cm diameter) and took a total of 2,272 measurements.

2. SITE DESCRIPTION

Measurements were conducted in the 1.6-ha Yamashiro Experimental Watershed (34°47'N, 135°50'E; 180–250 m ASL) in Japan. A broadleaf secondary forest covers the watershed and is dominated by *Quercus serrata*. In 1999, the total basal area occupied by stems larger than 3 cm diameter at breast height (DBH) was 20.7 m^2 ha^{-1}, and the aboveground biomass was 105.05 t ha^{-1}. From 1999 to 2002, the average litter fall was 5.16 t ha^{-1} $year^{-1}$, the average air temperature was 15.5℃, the average monthly temperature was 5.1–26.1℃, the warmth index was 125.6℃·month, and the

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average annual precipitation was 1,449.1 mm (Goto *et al*., 2003). Bedrock underlying the site is weathered granite, and the soil is generally sandy, immature, and thin (Araki *et al*., 1997).

3. METHODS

3.1 Relationships among soil respiration rate, soil temperature, and soil moisture content

The relationships among soil respiration rate (F_c; mg CO_2 m^{-2} s^{-1}), soil temperature (T_s; ℃), and soil moisture content ratio (θ; m^3 m^{-3}) are expressed by Equation (1). Equation (1) contains individual formula for the F_c–T_s relationship ($f(T_s)$) and the F_c– θ relationship ($f(\theta)$), which are multiplied together (e.g., Irvine *et al*., 2002; Subke *et al*., 2003, Liang *et al*., 2004):

$$F_c = af(T_s)f(\theta), \quad (1)$$

where 'a' is a constant.

Some of these studies, such as that of Subke *et al*. (2003), compared results using three types of functions for the F_c–T_s relationship and two types of functions for the F_c–□ relationship. In this study, Equations (2) and (3) are used for $f(T_s)$ and $f(\theta)$, respectively:

$$f(T_s) = \mathrm{EXP}(b\,T_s) \quad (2)$$

$$f(\theta) = \frac{\theta}{c+\theta}, \quad (3)$$

where 'b' and 'c' are constants.

Equation (2) is a widely used exponential function, and Equation (3) is a monotonic function (Bunnell *et al*., 1977). The F_c– θ relationship is commonly expressed by a function that forms a peak, for example, when soil respiration rate decreases during times of dryness or excessive moisture (e.g., Xu *et al*., 2001: Irvine *et al*., 2002). The soil in the Yamashiro Experimental Forest is derived from weathered granite, and is generally more porous than other forest soils (Yoshioka, 1996). Decreased respiration of such a soil during times of excessive moisture is not thought to happen. Thus, f(θ) is expressed by the simple relationship shown in Equation (3) in this study. Equations (1)–(3) are presented in a more complex form in Subke *et al*. (2003), but simplified forms are written here.

The variables to be identified are a, b, and c. They are identified using data from Measurement 1 (described below), and verified with data from Measurements 2 and 3. In this study, the values for T_s and θ are measurements taken at a depth of 5 cm.

3.2 Measurements of soil respiration rate, soil temperature, and soil moisture content

Various methods have been proposed for measuring F_c, including the dynamic closed-chamber method, the static closed-chamber method, the open-top chamber method, and the measurement of eddy correlation on the forest floor. The advantages and disadvantages of these methods have been compared by Norman *et al*. (1997) and Mizoguchi *et al*. (2003). This study used a manual chamber with an enclosed IRGA sensor, which is a highly portable system developed by Nobuhiro *et al*. (2003). This is a variation of the static closed-chamber method, and uses an IRGA sensor (GMT-222; VAISALA, Helsinki, Finland) inserted into a cylindrical chamber (diameter 9.1 cm, height 13.5 cm). The concentration of CO_2 in the chamber is measured every 10 s. F_c is calculated from the increased CO_2 concentration, based on Nakano *et al*. (2001) and Irvine *et al*. (2002), although these studies did not use the static closed-chamber methods. After confirming that the CO_2 concentration in the chamber increased linearly, the soil respiration rate was calculated

Table 1 Outline of Observation plots

PLOT No.	Slope Direction	Slope Degree	Alitude (m)	Basal Area (m^2)	Dominant Species
1.	N86°W	24°	215	0.341	*Quercus serrata*、
2.	N30°W	31°	207	0.265	*Alnus sieboldiana*
3.	S53°W	2°	188	0.131	*Clethra barvinervis*
4.	S22°E	26°	190	0.252	*Clethra barvinervis*
5.	S52°E	18°	222	0.322	*Ilex pedunculosa*

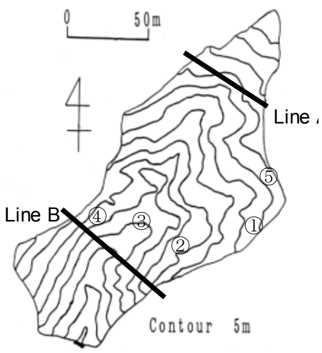


Fig.1 Topography and Location of Observation sites

from the rate of increase.

Actively photosynthesizing plants were not present in all of the soil collars. Measurements were divided into three categories: measurements made to identify the variables a, b, and c in Equations (1)–(3); fixed-point measurements to verify the identified variables a, b, and c; and mobile observations to verify the identified variables a, b, and c.

3.2.1 Measurements (Meas.) to identify variables (Meas. 1)

In order to obtain data for identifying the variables a, b, and c used in Equations (1)–(3), measurements were made at four plots (each 3 m × 0.5 m) on a ridge, a north-facing slope, a valley bottom and a south-facing slope (plots 1–4; Fig. 1 and Table 1) in the Yamashiro Experimental Forest. Twenty-four soil collars were set up at each location (total of 96 collars). Spacing between soil collars was about 10–20 cm. Soil respiration was measured 74 times, with a frequency of one to four times per month between June 2002 and May 2003 (Table 2). Each measurement consisted of one respiration rate measurement for each of the 24 soil collars. Chamber attachment time was 32 min in the winter months (December 2002–April 2003), and 12 min for measurements during the rest of the year. The soil respiration rate was calculated using the values measured 2 min after chamber attachment.

One soil moisture/temperature sensor (HYDRA; Stevens Vitel, Chantilly, VA, USA) was buried near the center of each plot, and soil temperature and soil moisture content at a depth of 5 cm were measured at 10-min intervals from June 2002 to June 2003.

3.2.2 Fixed-point measurements to verify the identified variables (Meas. 2)

Collection of Meas. 1 data was limited to a maximum of 16 days in plot 1, and thus a second data set (Meas. 2) was used to verify the temporal universality of the variables a, b, and c that had been identified using the data obtained from Meas. 1. Measurements were taken at plot 5, which was established on a ridge in the Yamashiro Experimental Forest (Fig. 1), where eight soil collars were installed. Spacing between the soil collars was about 10–20 cm. Measurements were taken a total of 30 times, at uneven intervals on 27 days in the time between September 2002 and July 2003. Each measurement consisted of respiration rate data from all eight chambers. Chamber mounting time was 32 min in the winter months (December 2002–April 2003) and 12 min during the rest of the year. The soil respiration

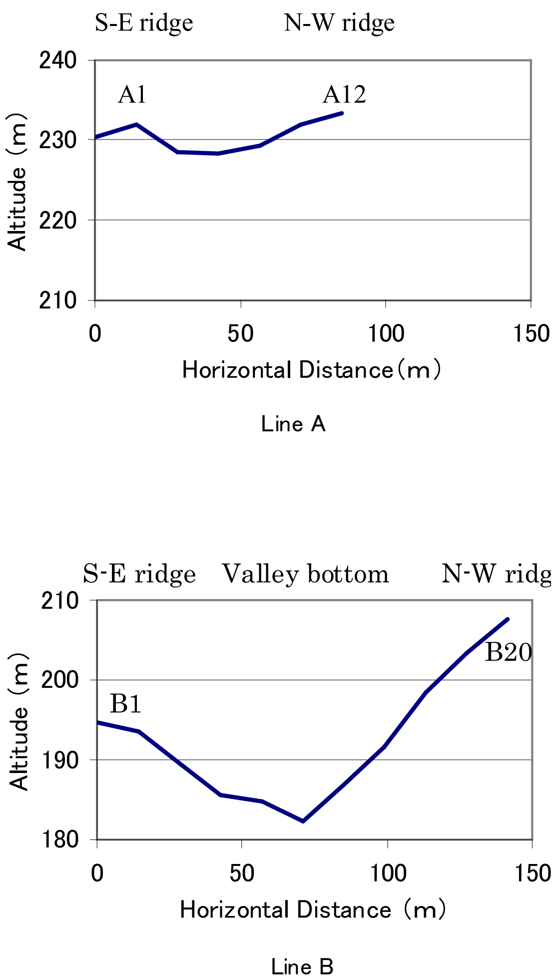


Fig. 2 Undulations of observation lines A and B.

rate was calculated using values measured 2 min after chamber mounting.

A soil moisture sensor (CS615; Campbell Scientific, Logan, UT, USA) and a temperature sensor (107 Temperature Probe; Campbell Scientific) were established in the center of the array of eight soil collars. Soil temperature and soil moisture content at a depth of 5 cm were measured at 10-min intervals from June 2002 to July 2003.

3.2.3 Mobile observations to verify the identified variables (Meas. 3)

Four measurement points for data obtained from Meas. 1 were chosen from each of the topographic categories within the watershed. However, because the spatial range was limited, a third data set (Meas. 3) was used to obtain data for verifying the spatial universality of the variables a, b, and c identified using data from Meas. 1. Two line transects across the Yamashiro Experimental Forest were established (Figs. 1 and 2). Line A was approximately 85 m long, and had an obvious ridge at each end and a flat area lacking well-defined valley topography in the middle. Line B, in contrast, was approximately 140 m long, and had an obvious valley with a stream in the middle. Ninety-six soil collars were installed along line A, and 160 soil collars along line B. The distance between the stream and the nearest soil collar was approximately 70 cm, and the vertical differential was approximately 1 m. Measurements were taken from 12:00 to 18:00 on 9 September 2003, and from 10:00 to 16:00 on 11 September 2003. Measurements were taken simultaneously at eight soil collars, each of which also had a soil moisture sensor (HYDRA) at a depth of 5 cm near its center. Thermocouples were used to measure soil temperature at a depth of 5 cm beside all soil collars.

4. Results and Discussion

4.1 Data used in identifying variables (Meas.1)

Measurements and calculations are summarized in Table 2. Let F_c be the average value of soil respiration rate in a single measurement at 24 soil collars, T_s be the average soil temperature, and θ be the average soil moisture content ratio during the measurement time. The standard deviation of the soil respiration rates for the 24 collars was large, roughly in the range of 20 to 40%. A scatter diagram for F_c and T_s (Fig. 3) shows a large degree of variation in the range above 0.05 mg CO_2 m^{-2} s^{-1}. A strong dependence on θ is evident, with the left side primarily consisting of measurements from June, where θ is 0.07–0.19 m^3 m^{-3}, and the right side primarily consisting of measurements from August, where θ is 0.03–0.10 m^3 m^{-3}. The distribution of values in Fig. 3 indicates that there was no bias due to location, and so we may conclude that temporal variation was greater than spatial variation in terms of the effects of soil moisture content on soil respiration rate. An exponential formula can be established for F_c and T_s at each of the four plots 1–4, as shown in Eqs. (4)–(7):

$$F_c = 0.0126\mathrm{EXP}\,(0.1014T_s) \quad (4)$$
$$F_c = 0.0111\mathrm{EXP}\,(0.1069T_s) \quad (5)$$
$$F_c = 0.0112\mathrm{EXP}\,(0.1060T_s) \quad (6)$$
$$F_c = 0.0167\mathrm{EXP}\,(0.0836T_s) \quad (7)$$

These four equations correspond to Q_{10} values of 2.76, 2.91, 2.89, and 2.31, and the correlation coefficients are 0.75, 0.80, 0.90 and 0.86, respectively. The values for plots 1–3 are roughly the same, whereas that for plot 4 is somewhat smaller.

F_c, T_s, and θ were used in identifying the variables to minimize the relative error indicated by Eq. (8):

$$\mathrm{RRSE} = \frac{\sqrt{\Sigma\left(F_{cal} - F_c\right)^2}}{\Sigma\left(F_c\right)}, \quad (8)$$

where F_{cal} is the calculated value for F_c and Σ is the sum of all applicable data.

The results yielded by Eq. (9), are: a = 0.0566, b = 0.0717, and c = 0.1089, with a RRSE of 23%:

$$F_c = 0.0566\mathrm{EXP}(0.0717T_s)\left(\frac{\theta}{0.1089 + \theta}\right). \quad (9)$$

F_c and F_{cal}, as indicated in Fig. 4, also include data for plot 4, which had a smaller Q_{10} than the other plots. A satisfactory result was obtained, with data plotting roughly along a 1:1 line. This supports the validity of using the functions given by Eqs. (1)–(3) for this study.

The soil respiration rate is affected not only by soil temperature and soil moisture content ratio, but also by a variety of other factors, including the amount of organic matter and roots in the soil, and the tree species present. The standard deviation of the soil respiration rate in the plots was large (roughly 20–40% of

Table 2 Observation results of Measurement 1 (Tamai *et al*., 2005b)

Observation date	Observation time	Plot No.	F_c	STD of F_c	T_s	θ	Observation date	Observation time	Plot No.	F_c	STD of F_c	T_s	θ
2002/6/26	11:00-13:55	1	0.101	0.020	12.77	0.077	2002/9/26	9:35-10:20	3	0.068	0.024	17.40	0.098
2002/6/26	14:45-17:40	1	0.102	0.029	13.11	0.077	2002/9/26	10:25-11:10	4	0.091	0.011	19.41	0.028
2002/6/26	11:00-13:55	2	0.130	0.041	14.78	0.180	2002/10/22	10:35-11:15	1	0.075	0.020	11.83	0.066
2002/6/26	14:45-17:40	2	0.136	0.035	15.79	0.170	2002/10/22	11:20-12:00	2	0.083	0.012	13.80	0.132
2002/6/26	11:00-13:55	3	0.112	0.021	15.72	0.108	2002/10/22	12:15-13:00	3	0.082	0.030	15.11	0.109
2002/6/26	14:45-17:40	3	0.116	0.018	16.75	0.106	2002/10/22	13:10-13:50	4	0.127	0.041	17.26	0.101
2002/6/26	11:00-13:55	4	0.173	0.046	16.73	0.141	2002/11/19	10:25-11:10	1	0.025	0.008	5.32	0.036
2002/6/26	14:45-17:40	4	0.182	0.043	17.89	0.138	2002/11/19	11:20-12:05	2	0.033	0.014	7.54	0.062
2002/6/27	11:00-13:55	1	0.101	0.031	13.16	0.073	2002/11/19	13:10-13:55	3	0.029	0.007	10.17	0.064
2002/6/27	14:00-16:55	1	0.095	0.028	13.46	0.072	2002/11/19	14:05-14:50	4	0.045	0.016	12.75	0.089
2002/6/27	11:00-13:55	2	0.123	0.032	16.04	0.143	2002/11/20	13:35-14:20	1	0.021	0.005	5.95	0.036
2002/6/27	14:00-16:55	2	0.124	0.034	16.26	0.138	2002/11/20	14:25-15:10	2	0.027	0.007	9.26	0.060
2002/6/27	11:00-13:55	3	0.110	0.017	17.29	0.105	2002/12/17	13:35-14:55	1	0.024	0.007	4.84	0.066
2002/6/27	14:00-16:55	3	0.118	0.019	17.52	0.104	2002/12/18	10:55-12:15	2	0.029	0.009	6.42	0.126
2002/6/27	11:00-13:55	4	0.167	0.042	18.40	0.180	2002/12/18	12:30-13:55	3	0.020	0.005	7.19	0.107
2002/6/27	14:00-16:55	4	0.170	0.042	18.52	0.190	2002/12/18	14:00-15:20	4	0.040	0.015	9.76	0.121
2002/7/22	13:20-14:00	1	0.121	0.039	21.10	0.059	2003/1/29	10:25-11:55	1	0.003	0.003	1.59	0.066
2002/7/22	14:30-15:10	2	0.176	0.061	25.62	0.107	2003/1/29	12:05-13:35	2	0.002	0.002	2.01	0.129
2002/7/25	11:55-12:45	3	0.172	0.028	25.99	0.090	2003/1/30	10:20-11:50	3	0.008	0.003	1.83	0.090
2002/7/25	13:00-13:50	4	0.173	0.040	27.66	0.112	2003/1/30	12:00-13:35	4	0.028	0.008	4.90	0.123
2002/8/7	11:30-14:25	1	0.071	0.037	21.35	0.034	2003/1/30	13:55-15:25	2	0.012	0.002	0.58	0.121
2002/8/7	14:30-17:40	1	0.065	0.031	21.95	0.034	2003/2/4	10:05-11:30	1	0.012	0.003	1.92	0.056
2002/8/7	11:30-14:25	2	0.105	0.031	26.56	0.045	2003/2/4	12:55-14:25	2	0.013	0.004	4.04	0.109
2002/8/7	14:30-17:40	2	0.107	0.031	27.76	0.044	2003/2/5	10:45-12:05	3	0.014	0.003	3.99	0.097
2002/8/7	11:30-14:25	3	0.151	0.039	27.23	0.065	2003/2/5	12:20-13:50	4	0.032	0.010	6.39	0.119
2002/8/7	14:30-17:25	3	0.144	0.020	27.59	0.063	2003/3/14	13:00-14:30	1	0.014	0.005	2.91	0.059
2002/8/8	9:00-11:55	1	0.065	0.028	20.86	0.033	2003/3/14	14:45-16:15	2	0.020	0.006	6.79	0.147
2002/8/8	12:00-14:55	1	0.064	0.025	21.34	0.033	2003/3/24	12:30-13:20	3	0.023	0.006	12.79	0.101
2002/8/8	9:00-11:55	2	0.099	0.029	25.22	0.041	2003/3/24	13:30-14:20	4	0.036	0.016	10.03	0.118
2002/8/8	12:00-14:55	2	0.106	0.034	26.29	0.041	2003/4/16	13:25-14:55	1	0.044	0.014	8.16	0.076
2002/8/8	9:00-11:55	3	0.124	0.043	25.43	0.059	2003/4/16	15:10-16:45	2	0.064	0.015	14.51	0.168
2002/8/8	12:00-14:55	3	0.126	0.035	26.53	0.058	2003/4/17	11:40-13:10	3	0.061	0.014	12.96	0.106
2002/8/8	9:00-11:55	4	0.184	0.057	28.61	0.096	2003/4/17	13:20-14:50	4	0.085	0.017	16.19	0.124
2002/8/8	12:00-14:55	4	0.190	0.057	30.09	0.096	2003/5/13	11:30-12:20	1	0.079	0.020	11.39	0.075
2002/9/25	14:35-15:15	1	0.042	0.010	15.55	0.030	2003/5/13	12:30-13:20	2	0.130	0.031	16.11	0.172
2002/9/25	15:25-16:05	2	0.065	0.017	19.18	0.046	2003/5/13	13:40-14:25	3	0.087	0.024	18.32	0.108
2002/9/26	11:36-11:47	1	0.035	0.016	14.60	0.050	2003/5/13	14:35-15:25	4	0.095	0.025	16.25	0.146

F_c: Soil respiration rate ($mgCO_2\ m^{-2}s^{-1}$),

STD of F_c: Standard deviation of soil respiration rate ($mgCO_2\ m^{-2}s^{-1}$)

T_s: Soil temperature (°C), θ: Soil moisture content ratio ($m^3\ m^{-3}$)

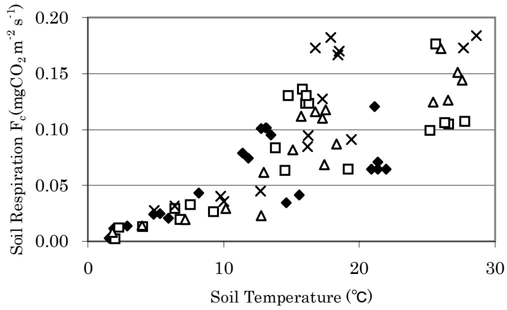


Fig.3 Comparison of Soil temperature (Ts) and soil respiration (Fc) in Measurement 1
Black diamond: Plot 1. White square: Plot 2.
White triangle: Plot 3 Cross: Plot 4

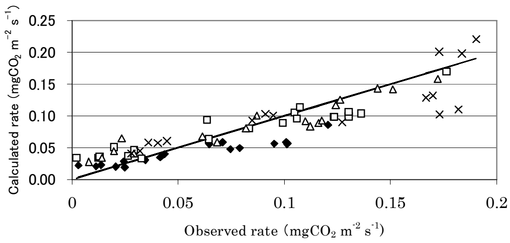


Fig.4 Comparison of Observed (F_c) and Calculated (F_{cal}) rate of soil respiration in Measurement 1.
Black diamond: Plot 1. White square: Plot 2.
White triangle: Plot 3 Cross: Plot 4

the average value), which was probably due to factors other than soil temperature and soil moisture content ratio. However, the F_c for all plots roughly matched the F_{cal} estimated from the soil temperature and moisture content ratio, as indicated in Eq. (9). This may indicate that effects due to factors other than soil temperature and soil moisture content ratio were canceled by averaging the measurements from the 24 soil collars. This issue will need to be investigated further.

4.2 Fixed-point measurements to verify the identified variables (Meas. 2)

Measured values are shown in Table 3. Let F_c be the average value for the soil respiration rate in a single measurement of eight soil collars, T_s be the average soil temperature, and θ be the average soil moisture content ratio during the observation time. The standard deviation for the eight collars was at most about 30%, and in many cases was 10% or less, primarily in winter. Figure 5 shows a comparison of F_c and F_{cal} from Eq. (9) identified in the previous section. In both cases, the results were satisfactory, with the data plotting roughly along a 1:1 line. The RRSE for Meas. 2 was 13%.

4.3 Mobile observations to verify the identified variables (Meas. 3)

Measured values are shown in Table 4. Let F_c be the average value for soil respiration rate in a single measurement of eight soil collars, T_s be the average soil temperature, and θ be the average soil moisture content ratio during the

Table 3 Observation results of Measurement 2

(Tamai *et al.*, 2005b)

Observation date	Observation Time	F_c	STD of F_c	T_s	θ
2002/9/25	14:00-14:12	0.047	0.004	15.37	0.060
2002/10/2	16:00-16:12	0.077	0.009	15.61	0.094
2002/10/9	14:00-14:12	0.083	0.001	13.22	0.094
2002/10/18	15:00-15:12	0.060	0.001	11.56	0.071
2002/10/22	10:00-10:12	0.068	0.020	11.73	0.096
2002/11/6	14:00-14:12	0.041	0.003	5.93	0.078
2002/11/14	13:00-13:12	0.040	0.003	6.19	0.080
2002/11/20	13:03-13:15	0.037	0.002	5.82	0.073
2002/12/17	12:52-13:24	0.037	0.007	4.91	0.095
2003/1/7	12:00-12:32	0.029	0.000	1.49	0.105
2003/1/17	12:00-12:32	0.033	0.002	2.59	0.093
2003/1/28	15:00-15:32	0.033	0.002	2.84	0.118
2003/2/4	12:02-12:34	0.031	0.002	1.89	0.109
2003/2/10	15:00-15:32	0.040	0.004	4.14	0.102
2003/2/18	15:00-15:32	0.036	0.002	2.75	0.125
2003/3/5	13:38-14:10	0.041	0.007	2.07	0.138
2003/3/14	12:00-12:32	0.032	0.002	2.59	0.133
2003/3/25	12:00-12:32	0.049	0.006	5.05	0.149
2003/4/10	12:00-12:32	0.040	0.006	4.78	0.147
2003/5/9	12:00-12:32	0.080	0.024	9.19	0.171
2003/5/22	13:00-13:12	0.080	0.013	11.45	0.155
2003/6/2	12:00-12:12	0.074	0.013	12.03	0.158
2003/6/2	13:00-13:12	0.082	0.016	12.15	0.156
2003/6/9	13:00-13:12	0.049	0.007	14.51	0.108
2003/6/9	14:00-14:12	0.053	0.012	14.64	0.110
2003/6/25	13:00-13:12	0.100	0.021	16.63	0.197
2003/6/25	14:00-14:12	0.115	0.026	16.65	0.194
2003/7/2	14:00-14:12	0.128	0.023	16.11	0.183
2003/7/9	14:12-14:24	0.120	0.021	18.96	0.174
2003/7/15	13:00-13:12	0.123	0.020	16.36	0.165

F_c: Soil respiration rate ($mgCO_2\ m^{-2}s^{-1}$).
STD of F_c: Standard deviation of soil respiration rate ($mgCO_2\ m^{-2}s^{-1}$).
T_s: Soil temperature (°C).
θ: Soil moisture content ratio ($m^3\ m^{-3}$).

Table 4 Observation results in Measurement 3.

(Tamai *et al*., 2005b)

2003/Sep./09

LineA

	Plot	Observation time	F_c	STD of F_c	T_s	θ
S-E ridge	A1	13:31-13:38 13:42-13:49	0.095	0.024	24.35	0.043
	A2	13:55-14:02	0.071	0.008	24.31	0.041
	A3	14:07-14:14	0.078	0.014	23.65	0.058
	A4	14:20-14:27	0.125	0.035	24.57	0.075
	A5	13:13-13:25	0.110	0.017	23.87	0.071
	A6	13:01-13:08	0.120	0.014	22.56	0.107
	A7	12:48-12:55	0.086	0.013	21.91	0.077
	A8	12:38-12:45	0.081	0.009	22.74	0.066
	A9	12:26-12:33	0.113	0.026	23.19	0.075
	A10	12:15-12:22	0.148	0.055	22.47	0.087
	A11	12:01-12:08	0.113	0.019	21.49	0.046
N-W ridge	A12	11:50-11:57	0.093	0.010	22.42	0.044

N-E side in Line B

	Plot	Observation time	F_c	STD of F_c	T_s	θ
S-E ridge	B1	15:49-15:56 15:59-16:06	0.093	0.021	23.34	--
	B2	15:30-15:37	0.082	0.006	23.14	0.072
	B3	15:19-15:26	0.087	0.010	22.47	0.032
	B4	15:05-15:12	0.098	0.031	22.41	0.107
	B5	16:40-16:47	0.103	0.020	22.16	0.055
	B6	16:50-16:57	0.101	0.029	21.80	0.114
	B7	17:01-17:08	0.089	0.013	21.44	0.140
	B8	17:12-17:19	0.102	0.014	21.56	0.094
	B9	17:23-17:30	0.077	0.005	21.72	0.090
Bottom of valley	B10	17:35-17:42 17:45-17:52	0.073	0.025	21.36	0.121

2003/Sep./11

Line B

	Plot	Observation time	F_c	STD of F_c	T_s	θ
S-E ridge	B1	13:54-14:01	0.089	0.023	24.61	0.070
	B2	14:05-14:12	0.109	0.017	23.62	0.071
	B3	14:16-14:23	0.100	0.028	23.02	0.056
	B4	14:27-14:34	0.087	0.029	22.47	0.078
	B5	14:39-14:46	0.089	0.022	22.82	0.069
	B6	14:50-14:57	0.107	0.035	22.45	0.078
	B7	15:01-15:08	0.095	0.007	22.32	0.075
	B8	15:12-15:19	0.112	0.013	21.72	0.055
	B9	13:25-13:32	0.073	0.011	21.62	0.082
Bottom of valley	B10	15:37-15:44	0.092	0.024	20.61	0.091
	B11	13:23-13:30	0.098	0.023	21.76	0.147
	B12	13:35-13:42	0.088	0.017	23.05	0.065
	B13	13:11-13:18	0.090	0.021	23.65	0.055
	B14	12:57-13:04	0.078	0.011	24.39	0.047
	B15	10:14-10:21 12:46-12:53	0.082	0.033	23.16	0.058
	B16	10:28-10:35	0.073	0.011	22.17	--
	B17	10:44-10:51	0.074	0.013	23.57	0.037
	B18	10:56-11:03	0.094	0.017	23.45	0.037
	B19	11:09-11:16	0.094	0.022	23.04	0.056
N-W ridge	B20	11:21-11:28	0.091	0.022	22.64	0.055

F_c: Soil respiration rate ($mgCO_2$ $m^{-2}s^{-1}$),
STD of F_c: Standard deviation of soil respiration rate ($mgCO_2$ $m^{-2}s^{-1}$)
T_s: Soil temperature (ºC),
θ: Soil moisture content ratio (m^3 m^{-3})

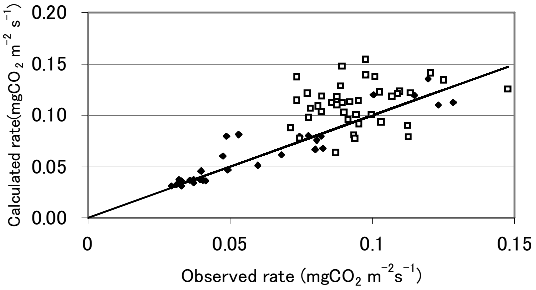


Fig.5 Comparison of Observed (F_c) and Calculated (F_{cal}) rate of soil respiration in Measurement 2 and 3.
Black dot: Measurement 2 (Plot 5).
White dot: Measurement 3 (Line A and B)

observation time. A comparison of F_c and F_{cal} as calculated using Eq. (9) is shown in Fig. 5. As explained in *Data used in identifying variables (Meas. 1)* above, the measured soil respiration rate is thought to be affected not only by soil temperature and moisture content, but also by a variety of other factors including the amount of organic matter and roots in the soil, and the tree species present. The variation in F_c in Meas. 3 is also thought to include effects resulting from the spatial variation of factors other than soil temperature and soil respiration. In spite of this, the RRSE in Meas. 3 was only 25%, roughly the same as the RRSE of 23% obtained when variables were identified based on the results of Meas. 1.

4.4 Potential for applying the identified variables to the entire watershed

The match between F_c (from Meas. 2 and 3), and F_{cal} (from Eq. (9)) was satisfactory in all cases. Nobuhiro *et al*. (2003) approximated the relationship between F_c and T_s at the Yamashiro Experimental Forest at a depth of 5 cm using an exponential formula similar to that given by Eq. (10):

$$F_c = a' \, EXP\,(b\,T_s), \quad (10)$$

where a' is a variable.

Equation (11) was obtained by comparing Eqs. (1)–(3) and Eq. (10):

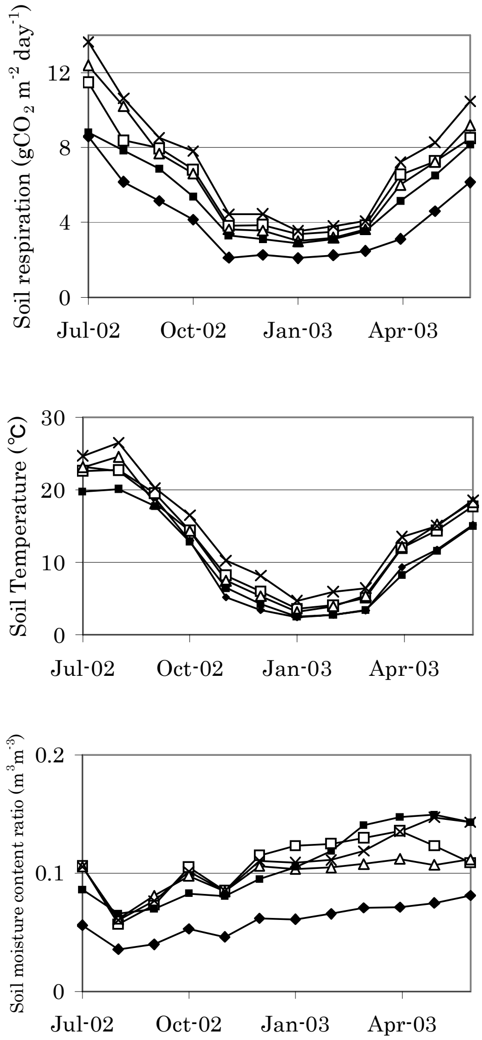
$$a' = a\frac{\theta}{c+\theta}. \quad (11)$$

Nobuhiro *et al*. (2003) reported that Q_{10} for soil temperature at a depth of 5 cm was 2.03, a' = 0.0202 and b = 0.0707 in a ridge location, whereas Q_{10} was 2.02, a' = 0.0566 and b = 0.0705 in a valley location. Although the ridge plot of Nobuhiro *et al*. (2003) was the same location as plot 1 in this study, Q_{10} at plot 1 in this study was larger than that determined by Nobuhiro (2003). This may be because the measurements by Nobuhiro *et al*. (2003) did not include times when the soil moisture content was high. Nobuhiro *et al*. (2003) gave a value for variable b that was similar to that in this study. For the ridge plot, a' = 0.0202 corresponded to the case when θ was 4% in Eq. (11), and although rather small, it is not an unexpected value. The value of a' for the valley-bottom plot (0.0566) was identical to that in this study, and was large enough to compare with Eq. (9) in this study. This may be the result of other factors, such as the volume of roots and organic matter in the soil.

Nobuhiro *et al*. (2003) took measurements a total of 16 times, using four soil collars in the valley-bottom plot. This is a very small data set compared to the 2,272 measurements taken from 360 soil collars in this study. This supports the conclusion that it is possible to evaluate soil respiration rate precisely (RRSE = 25% using Eq. (9)) for almost all locations in a small watershed such as the Yamashiro Experimental Forest. The 25% RRSE value was derived from Meas. 3, which had the highest percentage error among the test results of Meas. 2 and 3. The standard deviation for soil respiration rate in the plot is likely to have enough precision for practical use, provided that one takes into consideration the fact that the standard deviation for soil respiration rate in the plot was 10–40% of the average value.

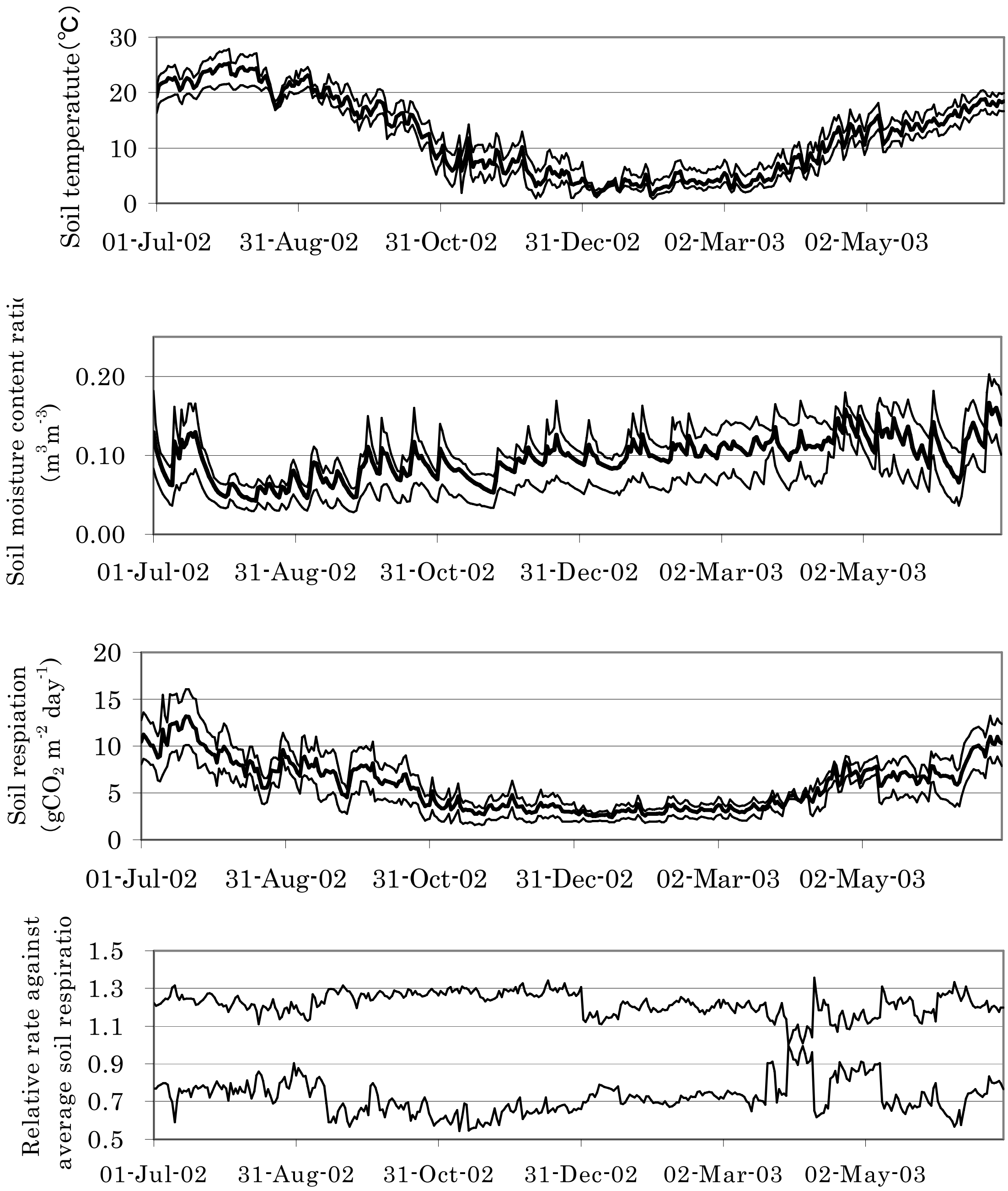
4.5 Estimation of annual soil respiration

The spatial variation in soil respiration rates was investigated by calculating and comparing rates at plots 1–5 from July 2002 to June 2003. The daily average soil temperature and soil moisture content ratio at 5 cm depth, as monitored at plots 1–5, were entered into Eq. (9), and the calculated value was taken to be the daily soil respiration rate. The average value for each month is shown in Fig. 6. The highest soil respiration rate for all months was in plot 4, the lowest in plot 1, and the second lowest in plot 5. This is because the soil temperature was low at ridge plots 1 and 5, soil moisture content was low at plot 1, and soil temperature was high at plot 4. The likely reason why soil temperature was high at plot 4 is that it is a south-facing slope with good sun exposure, and ridge plots 1 and 5 likely had a low soil temperature because wind speed was comparatively high, causing major heat loss. Figure 7 shows daily variation



Figs.-6 Estimated soil respiration rate in Plot 1-5.
Upper: soil respiration,
Middle: Soil temperature
Lower: Soil moisture content ratio
Black circle: Plot 1, White square: Plot 2,
White triangle: Plot 3, Cross: Plot 4,
Black square: Plot 5

(Tamai *et al*., 2005b)



Figs.7 The annual courses (July, 2002 – June, 2003) of soil temperature (1st level), soil moisture content ratio (2nd level), soil respiration (3rd level) and relative rate of each plots against average soil respiration (4th level) in plots 1-5.
Thick line: averaged values in plots 1-5
Thin lines: maximum and minimum values in plots 1-5.

(Tamai *et al.*, 2005b)

Table 5 Comparison of annual soil respiration rate with previous studies. (Tamai *et al*., 2005b)

No.	Location	Forest type	Reference	Annual soil respiration	Annual averaged air temperature	Annual precipitation
1	Yamashiro Experimental Forest, Japan	Broad-leaved secondary forest	This study	15.6-26.0	15.5	1499.1
2	Oregon, U.S.A.	Ponderosa pine forest 14yrs.	Irvine et al., 2002	15.7-19.0	7.5	552
3	Oregon, U.S.A.	Ponderosa pine forest mixed 50yrs. and 250yrs.	Irvine et al., 2002	17.7-21.9	8.1	524
4	Tennessee, U.S.A.	Deciduous broad-leaved forest	Curtis et al., 2002	34.8	13.8	1352
5	Indiana, U.S.A.	Deciduous broad-leaved forest	Curtis et al., 2002	44.3	11.1	1012
6	Massachusetts, U.S.A.	Deciduous broad-leaved forest	Curtis et al., 2002	29.3	7.1	1066
7	Michigan, U.S.A.	Deciduous broad-leaved forest	Curtis et al., 2002	41.5	6.2	750
8	Wisconsin, U.S.A.	Deciduous broad-leaved forest	Curtis et al., 2002	29.7	4.8	776
9	Hokkaido, Japan	Japanese larch forest 45yrs.	Liang et al., 2004	24.4-26.4	7.3	1250
11	Kumamoto, Japan	Japanese ceder forest with density of 16,000stem ha^{-1}	Ohashi et al., 1999	18.3-21.7	16.2	1970
12	Kumamoto, Japan	Japanese ceder forest with density of 8,000stem ha^{-1}	Ohashi et al., 1999	25.7-30.6	16.2	1970
13	Thailand	Evergreen forest	Hashimoto et al., 2004	93.9	20	2084.1

Annual soil respiration:t CO_2 ha^{-2} $year^{-1}$
Annual averaged air temperature:°C
Annual precipitation:mm

in the average, maximum, and minimum soil respiration rate, daily soil temperature, and daily soil moisture content ratio for the five plots. Throughout most of the study period, increases and decreases in the three curves occurred almost simultaneously (3rd level of Fig. 7). The maximum and minimum values varied from 50 to 140% of the average value (4th level in Fig. 7). The time series data for soil respiration at the five plots covaried at different locations, with spatial variation in the range of 50 to 140% of the average value.

4.6 Estimation of annual soil respiration rate and its validity

The validity of Eq. (9) was confirmed by comparing the annual soil respiration rate estimated using Eq. (9) against values given in previous reports.

The cumulative value for 1 year, obtained from the average values for daily soil respiration rate, was 21.3 t CO_2 ha^{-2} $year^{-1}$. The cumulative values obtained from maximum and minimum values were, respectively, 26.0 t CO_2 ha^{-2} $year^{-1}$ (122% of the cumulative value obtained from average values) and 15.6 t CO_2 ha^{-2} $year^{-1}$ (73% of the cumulative value obtained from average values).

Raich *et al*. (1992) reported on global forest soil respiration rates, based on reports from the years 1960–1990. The rates were: 11.8 ± 1.1 t CO_2 ha^{-2} $year^{-1}$ in boreal forests (16 studies), 25.0 ± 3.5 t CO_2 ha^{-2} $year^{-1}$ in temperate coniferous forests (23 studies), 23.7 ± 1.9 t CO_2 ha^{-2} $year^{-1}$ in temperature broadleaf forests (29 studies), 24.7 ± 4.9 t CO_2 ha^{-2} $year^{-1}$ in tropical xerophile forests (4 studies), and 46.2 ± 2.1 t CO_2 ha^{-2} $year^{-1}$ in tropical rain forest (10 studies). The minimum value obtained in this study (15.6 t CO_2 ha^{-2} $year^{-1}$) does not fall within the range of values for temperate forests provided by Raich *et al*. (1992), although the average value (21.3 t CO_2 ha^{-2} $year^{-1}$) and the maximum value (26.0 t CO_2 ha^{-2} $year^{-1}$) do fall within their range. This study's estimates of annual soil respiration rate compare favorably with other studies (Table 5; Fig. 8), such as that for cedar forest in Kumamoto (Ohashi *et al*., 1999). This once again demonstrates that the estimated values derived by this study are within the range of previous studies, and that Eq. (9) is valid.

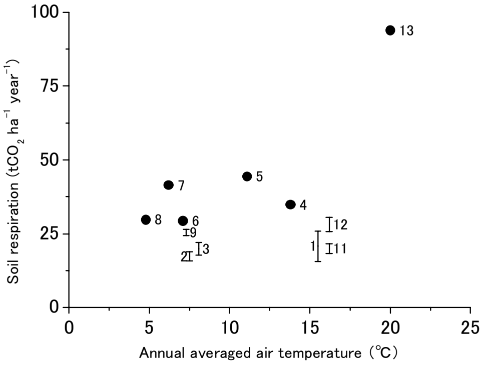


Fig.-8 Comparison between annual soil respiration and annual averaged air temperature in previous studies. (Tamai et al., 2005b)
Numbers show the reported case in Table-5.

5. Conclusions

This study has yielded an equation that estimates soil respiration rate using soil temperature and soil moisture content ratio with a precision of 25% (relative error). The equation was used to calculate time series data for daily soil respiration rate at five plots in a forest watershed. The five plots represented different topographical categories in the watershed (ridge, valley bottom, and south/north-facing slope), such that the time series and spatial variation results adequately reflect the overall characteristics and spatial variations within the Yamashiro Experimental Forest.

For the purpose of evaluating spatial variation in time series data, it is best to have a high spatial density of measurements. Soil respiration, however, is difficult to measure at a large number of points. Fortuitously, we were able to estimate time series data on soil respiration rate based on soil temperature and soil moisture content, which are considerably easier to monitor. Time series data for soil respiration rate can also be superficially estimated using a soil temperature and soil moisture simulation model, based on the heat budget at the ground surface (Hirota *et al*., 1996), or a separate model for predicting soil moisture fluctuation in watersheds (Kubota *et al*., 1987).

The time series data on soil respiration rate and its spatial variation from this study will be used in future work to evaluate the carbon-fixing capacity of forests on complex topographies by comparing them with time series data on CO_2 flux above the forest canopy.

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Site Info

Carbon Metabolism of an Old-Growth Temperate Mixed Forest: Fluxes Measurement at ChinaFLUX Changbai Mt. Site

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Old-growth forests are generally considered to be insignificant carbon sinks while several recent process studies have indicated that some old forest ecosystems do not reach a steady state carbon flux and can continue to act as a net sink for atmospheric carbon dioxide over several decades or longer. Long-term measurements are needed to clarify the role of old-growth forests and to reduce the uncertainties in global carbon accounting. Fluxes measurement in ChinaFLUX Changbai Mt. site is one of the few efforts to make this. Multi ways, such as Chambers measurements, eddy-covariance technique, inventory methods, remote sensing and modeling were applied to investigate carbon metabolism of this Chinese old-growth forest.

The flux tower lies in No. 1 Plot at the Forest Ecosystem Open Research Station of Changbai Mountains (128°28’E and 42°24’ N, Jilin Province, P. R. China), Chinese Academy of Sciences. Measurements were conducted since August 2002. The climate of site belongs to the temperate continental climate influenced

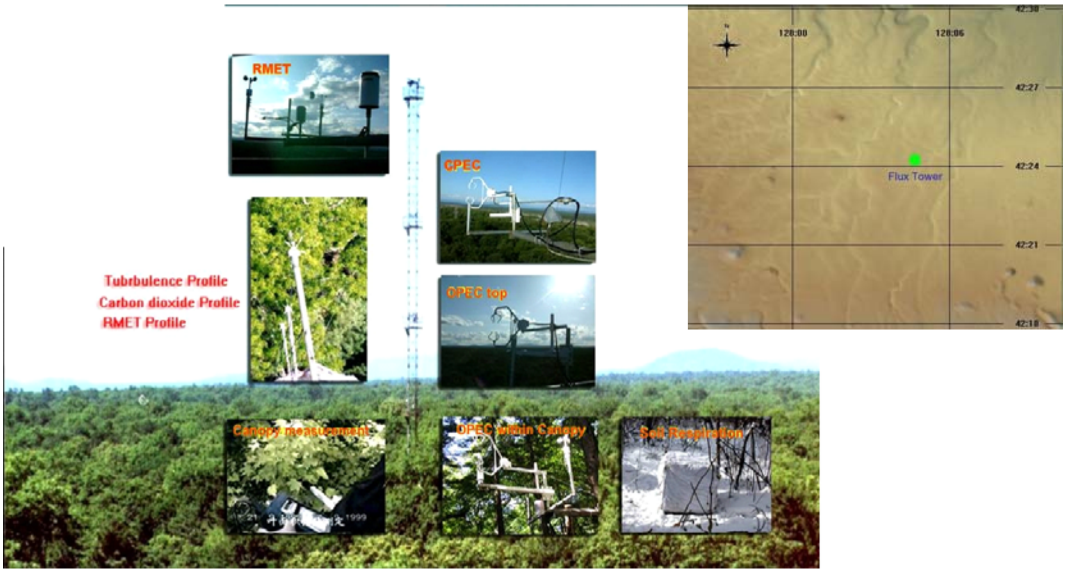

Figure 1 The location of Changbai Mt site flux tower with instruments installed

by monsoon, having the prominent characteristics of mid-latitudinal upland climate. The area has four obvious different seasons as windy spring, hot and rainy summer, cool autumn and cold winter. The annual mean temperature of flux site is 0.9 ~ 4.0°C, total precipitation is 693.9 mm·a-1 (evaluated between 1982 and 2004). The site provides a maximum fetch of 60 km in the E-S-W direction and a minimum of 500 m in the NE direction. The area is covered by on average 200-year-old, multi-storied, uneven-aged, multi-species mixed forest consisting of Korean pine (*Pinus koraiensis*), *Tilia amurensis, Acer mono, Fraxinus mandshurica, Quercus mongolica* etc. A dense understory, consisting of multi-species broad-leaved shrub, has coverage of 40%. The mean canopy height is 26 m. The peak leaf area index is about 6.1. The soil is classified as dark brown forest soil. The landscape is very flat. Figure 1.

A coexisting closed-open-path eddy covariance measurement system was installed at 40 m. The system consists of a Li7500 open-path sensor (IRGA, Li-Cor, USA), LI7000 closed-path IRGA analyzer (LI-Cor,USA) and a 3-D ultrasonic anemometer (CSAT3, Campbell Scientific, USA). Instruments were sampled at 10 Hz. Half-hourly fluxes are calculated on-line and collected by CR5000 data logger (Campbell Scientific, USA). A 7-level CO_2 profile is measured by a CR10X (Campbell, USA) controlled multi-port system connected to a Li820 gas analyzer. Calibration of the IRGAs against standard gases is done automatically every 2 hours. Meteorological variables, rainfall, radiation components, temperatures, wind speed, wind direction and humidity, PAR etc, are measured at 7 levels and sampled every 2 s and stored as half-hour statistics (CR23X, Campbell, USA). Eco-physiological parameters of vegetation were measured except winter. Static chambers were applied to measure respiration components weekly since 2002.

The primary results show that this old-growth forest was a carbon sink although strongly regulated by climate (Table 1).

Table 1 Carbon budget of broadleaved Korean pine forest * **Units gC m^{-2} yr^{-1}**

Year	NEE	NPP		RE	
	EC	EC	INV	EC	CHB
2003	**-278**	**626±53**	**945±105**	**1054**	**1050**
2004	**-171**	**608±51**	**925±102**	**1124**	**1076**

* EC: by eddy-covariance, INV: by inventory , CHB: by chamber methods

New Policy and Membership of AsiaFlux

AsiaFlux was established in September 1999 and its web page was launched in March 2000. The first AsiaFlux workshop was held in September 2000 (WS2000) in Sapporo. Over the past eight years, AsiaFlux has grown from about 20 sites to over 100 sites that distribute in various terrestrial ecosystems throughout the East, Northeast and Southeast Asian regions. The WS2002, WS2003, WS2005, and WS2006 were held in Jeju, Beijing, Fujiyoshida, and Chiang Mai, respectively; and about 150 participants attended each of the workshop.

Yasumi Fujinuma, Leader of Network Management Sub-workgroup

AsiaFlux

AsiaFlux is a regional research network bringing together scientists from university and institution in Asia to study the exchanges of carbon dioxide, water vapor, and energy between terrestrial ecosystems and the atmosphere across daily to inter-annual time scales.

General Objectives

1. To investigate the magnitude of the carbon sources/sinks for a range of terrestrial ecosystems, in respect of climate, species, age, and geographical locations;
2. To understand the effect of inter- and intra-annual climate variations on the magnitude of carbon, water and energy exchanges of terrestrial ecosystems;
3. To investigate the role of soil, wood and leaves biomass respiration on the ecosystem carbon exchanges;
4. To validate the micrometeorological method against the standard biometric approach;
5. To investigate the role of forest management on the ecosystem carbon, water and energy cycles;
6. To study the effects of natural (wild fires, insect pests, typhoons, etc.) and human induced (logging, land use change, overgrazing, etc.) disturbances on carbon and water cycles in Asian terrestrial ecosystems;
7. To coordinate the tower-based carbon flux research group with the atmospheric, oceanic, soil, and water research groups;
8. To bridge the gaps between the ground based measurements in both space and time and the products of remote sensing and modeling approaches.

Establishment of JapanFlux

Takashi Hirano (Hokkaido University)

JapanFlux has been established in December 2006, as a network of Japanese flux research groups, under the umbrella of AsiaFlux. The independence of JapanFlux should clarify the function of AsiaFlux and defines it as the comprehensive organization of sub-regional networks in Asia.

We believe this new framework will support Japanese researchers who are related to tower flux observation and terrestrial carbon budget researches, to integrate their studies and synthesize the results smoothly. It shall also tighten the collaboration among research groups. We hope this newborn wing of AsiaFlux will encourage further establishment of flux research communities from non-networked region in Asia.

Passing of Prof. Kida

It is with deep regret that we must inform you Dr. Hideji Kida passed away on November 13 at the age of 64. He had been a member of the AsiaFlux steering committee since its establishment.

He was professor emeritus at Kyoto University, Internationally recognized atmospheric science researcher, served as a councilor of the Japan Geoscience Union and director of the Meteorological Society of Japan.

We are deeply sorry for the loss with remembrance of him and his great achievement.

AsiaFlux Newsletter Special Issue

National report from TC2006-participants

Publication of the special issue has been postponed to late January.

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Editor's Note

The core methodology of my research is tunable diode laser absorption spectroscopy (TDLAS) and is supplemented by flask sampling, mass spectrometry, and the eddy covariance technique. Thank all authors for their support for AsiaFlux Newsletter 20.

The editor of AsiaFlux Newsletter No.20:
Xue-Fa WEN
(Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences)

The editor of AsiaFlux Newsletter No.21 will be Kenzo Kitamura (Forestry and Forest Products Research Institute).