AsiaFlux Workshop 2011

"Bridging Ecosystem Science to Services and Stewardship"

PROCEEDINGS

November 9 - 11, 2011

Universiti Teknologi Malaysia, Johor Bahru

Organized by

AsiaFlux Steering Commitee

Co- Organized by

Universiti Teknologi Malaysia (UTM)
Forest Research Institute Malaysia (FRIM)
Malaysian Palm Oil Board (MPOB)
Japan Society for Promotion of Science (JSPS)
National Natural Science Foundation of China (NSFC)
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National Institute for Environmental Studies, Japan (NIES)
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AsiaFlux was established in 1999 as the Asian arm of FLUXNET, the worldwide flux research network and one of the potential components of Global Earth Observation System of Systems (GEOSS). Since the establishment of AsiaFlux, we have had the workshop annually to biennially, but only once in Southeast Asia - in Cheng Mai, Thailand in 2006. AsiaFlux Workshop 2011 in Universiti Teknologi Malaysia (UTM), Johor Bahru is the second workshop to take place in Southeast Asia.

The theme of the workshop 'Bridging Ecosystem Science to Services and Stewardship' is a part of our continuous endeavors towards the fulfillment of the AsiaFlux mission: bringing Asia's key ecosystems under observation to develop and transfer scientific knowledge which ensure the quality and sustainability of life in Asia. Ecosystem science, service and stewardship are the three pillars of the AsiaFlux vision towards regional and global sustainability. Due to global climate change; population increase; rapid economic growth; and resultant changes in land usage, terrestrial ecosystems, particularly in Southeast Asia, are faced with critical issues which lead to degradation of ecosystem services, such as changes in carbon, water and biogeochemical cycles; degradation of soil and freshwater; biodiversity loss; increasing scarcity of freshwater for agricultural use; chemical pollution; weakening of cultural identity, and so on. Some of these issues are also becoming apparent in other regions of Asia subject to monsoons. In applying our expertise on flux studies in conjunction with cross-disciplinary collaborations, how can we reach a better and more accurate understanding of those issues? How can we exercise resilience-based ecosystem stewardship to mitigate the impact of these issues for sustainable ecosystem management? These will be amongst the discussions we expect to take place in the upcoming workshop. We also highly anticipate presentations related to our short-term vision of providing the first ACB (the Asian Carbon and water Budget) report, such as those on quantifying patterns and variability of carbon/water/nutrient cycles in monsoon-effected Asia and assessing the roles of these cycles in the global context. In addition we anticipate presentations on technological innovation for the synthesis to upscale carbon/water fluxes at local, regional, and continental scales.

Fifteen flux sites in Southeast Asia have already joined and been registered to the AsiaFlux network as of August 1, 2011. However, more study sites undoubtedly exist in Malaysia and surrounding countries, with a considerable number of scientists from all over the world working at these. AsiaFlux Workshop 2011 will also provide those scientists and anyone who are interested in ecosystem science in Southeast Asia with a forum to congregate, share information, and discuss future collaborations to consolidate and strengthen the Southeast Asian flux site networks. Let's meet in Johor Bahru in November!

Joon Kim, Akira Miyata and Shenggong
Chair & Vice-Charis of AsiaFlux

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AsiaFlux Offices

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

AsiaFlux Seoul Office.
Bld, 36/Rm, Souel National University
1 Gwanak-ro, Gwanak-gu, Seoul 151-921, Korea
Ph: +82-2-871-0235 Fax:+82-2-312-5691
E-mail:ms-kang@yonsei.ac.kr

AsiaFlux Beijing Office.
Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science
A11 Datun Road, Anwai, Beijing 100101, China
Ph: +86-10-64889808 Fax:+86-10-64868962
E-mail:fuyl@igsnrr.ac.cn

AsiaFlux Workshop 2011 Schedule

	8	9	10	11	12	13	14	15	16	17	18-
8-Nov								Registration (15:00-17:00)			
9-Nov	Registration (8:00-9:00)	Opening (9:00-9:30)	Plenary Session (9:30-10:30)	Break (10:30-10:50)	Oral Session 1 (10:50-12:20)	Lunch (12:20-14:00)	Plenary Session (14:00-15:00)	Oral Session 2 (15:00-16:00)	Break (16:00-16:30)	Oral Session 3 (16:30-18:00)	Galla Dinner (20:00-23:00)
10-Nov		Plenary Session (8:30-9:30)	Oral Session 4 (9:30-10:45)	Break (10:45-11:15)	Oral Session 5 (11:15-12:30)	Lunch (12:30-14:00)	Plenary Session (14:00-15:00)	Regional Reports & Discussions (15:00-16:30)		Poster Session (16:30-18:00)	Young Scientist Meeting (19:30-21:30)
11-Nov		Oral Session 6 (8:30-10:30)		Break (10:30-10:45)	Oral Session 7 (10:45-12:30)	Lunch (12:30-13:45)	Oral Session 8 (13:45-15:30)	Discussions (15:30-16:00)	Closing (16:00-)		
12-Nov	Field trips and Training course										
13-Nov	Training course										

* Opening, Plenary & Oral Sessions : Senate Hall at UTM
* Posters and Buisiness Displays : Banquet Hall at UTM
* Galla Dinner : Pulai Spring Resort (Transport will be provided from UTM)
* Young Scientist Meeting : Bilik Mesyuarat Utama at UTM

AsiaFlux Workshop 2011 Program

Oral Session

November 9, 2011 (Wednesday)

08:00-09:00	**Registration**		
Welcome Addresses			**9 November 09:00-09:30**
09:00-09:30	Chair of Local Organizing Committee Chair of AsiaFlux Vice Chancellor- Universiti Teknologi Malaysia		
Plenary session: Tropical ecosystem in Asia			**9 November 09:30-10:30**
09:30-10:00	WO001	Tropical peatland and indication of (Green House Gaseous) GHGs	Lulie Melling
10:00-10:30	WO002	Effects land surface type, land use, and land use change on aquatic-atmosphere fluxes of CO_2 from tropical forests and peat lands of Borneo	Walter Oechel
10:30-10:50	**Break**		
Oral session 1: Tropical wetland in Asia			**9 November 10:50-12:20** **(Chair: Lulie Melling)**
10:50-11:05	WO004	Influence of El Niño / La Niña events (2008-2010) on ecosystem CO_2 exchange in flooded and non-flooded rice fields in the Philippines	Ma. Carmelita R. Alberto
11:05-11:20	WO022	Modeling ecohydrological controls on ecosystem net CO_2 exchange of a tropical bog	Robert Fraser Grant
11:20-11:35	WO021	Modeling ecohydrological controls on plant water relations and ecosystem energy balance of a tropical bog	Robert Fraser Grant
11:35-11:50	WO046	Quantify biosphere-atmosphere interactions in an estuarial grass marsh ecosystem by using eddy-covariance technique	Jehn-Yih Juang
11:50-12:05	WO026	Ecosystem water use efficiency for a reed marsh in Liaohe Delta, China	Li Zhou
12:05-12:20	WO045	Carbon storage of Caimpugan peatland in Agusan marsh, Philippines: its role in greenhouse gas mitigation and analysis of its ecosystem threats	Van Leeah Bautista Alibo
12:20-14:00	**Lunch**		
Plenary session: Regional carbon flux			**9 November 14:00-15:00**
14:00-14:30	WO056	Estimating Net Primary Productivity of Malaysian Tropical Forest using Remote Sensing Techniques	Ab Latif Ibrahim
14:30-15:00	WO051	The RECCAP/APN south and southeast Asian greenhouse gases budgets	Prabir K. Patra

Oral session 2: **Remote sensing and modeling 9 November 15:00-16:00** **(Chair: Ke-Sheng Cheng)**			
15:00-15:15	WO054	Monitoring paddy field carbon and evapotranspiration fluxes using field hyperspectral reflectance measurements - An experimental study in Northern Taiwan	Ke-Sheng Cheng
15:15-15:30	WO044	Validation and improvement of MODIS gross primary productivity in typical forest ecosystems of East Asia	Yanlian Zhou
15:30-15:45	WO037	Impacts of climate change on ecosystems in Jeju Island, Korea	Gwangyong Choi
15:45-16:00	WO047	Relationship between clouds, radiation and canopy productivity in savannas	Kasturi Devi Kanniah
16:00-16:30	**Break**		
Oral session 3: **Improvement in flux measurement techniques 9 November 16:30-18:00** **(Chair: Yoshinobu Harazono)**			
16:30-16:45	WO007	Advantages of fast mixing ratio estimation in an enclosed gas analyzer	James Chacko Kathilankal
16:45-17:00	WO003	The impact of changes in barometricpressure on landfill methane emission	Liukang Xu
17:00-17:15	WO011	Humidity correction for trace gas flux by chamber measurements	Yoshinobu Harazono
17:15-17:30	WO015	Photosynthesis under foggy conditions - a laboratory experiment	Shih-Chieh Chang
17:30-17:45	WO025	A semi-parametric multivariate gap-filling model for eddy covariance fluxes: evergreen forest latent heat flux in central Taiwan as an example	Yi-Ying Chen
17:45-18:00	WO029	Pressure correction to the long-term measurement of carbon dioxide flux	Junhui Zhang
20:00-23:00	**Gala dinner at Pulai Springs Resort**		

November 10, 2011 (Thursday)

Plenary session: Tropical forest ecosystem in Asia			**10 November 08:30-09:30**
08:30-09:00	WO057	Carbon sequestration in oil palm plantations	Khalid Harun
09:00-09:30	WO013	Impact of climate change on canopy CO_2 and H_2O exchange of a tropical rainforest in peninsular Malaysia, Pasoh	Yoshiko Kosugi
Oral session 4: Asian tropical forest ecosystem			**10 November 09:30-10:45**
(Chair : Khalid Harun)			
09:30-09:45	WO009	The carbon balance of a tropical rubber plantation	Zheng-Hong Tan
09:45-10:00	WO010	Rubber plantation act as water pumps in tropical China	Yi-Ping Zhang
10:00-10:15	WO041	The relationship of vegetation distribution and carbon storage in subtropical broad-leaves plantation in southern Taiwan	Po-Neng Chiang
10:15-10:30	WO042	The relationship of soil respiration variation and carbon storage in subtropical broad-leaves plantation in southern Taiwan	Yu Jui-Chu
10:30-10:45	WO049	Effects of tree species on soil microbial biomass and soil respiration in a subtropical plantation of east Taiwan	Chiao-Ping Wang
10:45-11:15	**Break**		
Oral session 5: Various ecosystems in Asia			**10 November 11:15-12:30**
(Chair: Takashi Hirano)			
11:15-11:30	WO036	Great carbon sink in an alpine *Kobresia* wetland in the hinterland on the Tibetan plateau	Peili Shi
11:30-11:45	WO014	CO_2 flux observation of wetland in the central part of the Tibetan plateau	Mingyuan Du
11:45-12:00	WO023	Rangelands carbon sequestration on Tibet plateau - challenges and opportunities	Xin-Quan Zhao
12:00-12:15	WO027	Measurements of carbon dioxide fluxes and energy balance over a suburban ecosystem in a tropical city	Matthias Roth
12:15-12:30	WO005	Evapotranspiration and climatic suitability of rice planting region in China	Juqi Duan
12:30-14:00	**Lunch**		
Plenary session: Networking			**10 November 14:00-16:30**
14:00-14:30	WO050	Fluxnet – a unique opportunity to integrate data, knowledge and people	Dario Papale
14:30-15:00	WO055	Networking flux researches to assess the carbon balance of tropical peatland ecosystems in se Asia	Takashi Hirano
15:00-16:30	Regional Reports and Discussions		
Poster session (16:30-18:00)			
Young Scientist meeting (19:30-21:30)			

November 11, 2011 (Friday)

Oral session 6: CarboEastAsia I		**11 November 08:30-10:30**	
		(Chair: Huimin Wang)	
08:30-09:00	WO038	Lessons learned from CarboEastAsia: back to basics	Joon Kim
09:00-09:15	WO019	Spatial and temporal patterns of the carbon budget in Asia and the uncertainty caused by different gap-filling procedures	Nobuko Saigusa
09:15-09:30	WO040	Environmental controls of the variability of radiation use efficiency across different forest ecosystems in East Asia	Leiming Zhang
09:30-09:45	WO020	Effects of biotic or abiotic factors on the spatial pattern of WUE among ecosystems in China	Xianjin Zhu
09:45-10:00	WO028	Characterizing the spring recovery rate of canopy photosynthesis in temperate forest and grassland ecosystems using flux data	Yuling Fu
10:00-10:15	WO039	Underestimated effects of low temperature during early growing season on carbon sequestration of a subtropical coniferous plantation	Huimin Wang
10:15-10:30	WO043	Uncertainty in eddy covariance measurements of carbon flux at deciduous and coniferous forests in complex terrain, Korea	Hyojung Kwon
10:30-10:45	**Break**		
Oral session 7: CarboEastAsia II		**11 November 10:45-12:30**	
		(Chair: Young Hee Lee)	
10:45-11:00	WO016	Lessons learned from CarboEastAsia MIP: Current status of terrestrial carbon cycle modeling in Asia	Kazuhito Ichii
11:00-11:15	WO024	An evaluation of community land model (CLM) 3.5-CN at grassland	Young-Hee Lee
11:15-11:30	WO018	An evaluation of community land model (CLM) 3.5-CN over temperate deciduous forest	Hee-Jeong Lim
11:30-11:45	WO032	Simulating the effects of plantation on carbon assimilation and evapotranspiration in a subtropical catchment utilizing a hydro-ecological model	Shaoqiang Wang
11:45-12:00	WO033	A multi-site simulation of different forest ecosystems in East Asia based on PnET-CN model	Hao Shi
12:00-12:15	WO017	Model based estimate of global carbon budget with optimization: toward application of GOSAT products	Masayuki Kondo
12:15-12:30	WO031	Mapping 500 m net primary productivity and water use efficiency in China using multi-angle remote sensing data	Weimin Ju
12:30-13:45	**Lunch**		

Oral session 8: CarboEastAsia Part III 11 November 13:45-16:00 (Chair: Masahito Ueyama)			
13:45-14:00	WO008	Soil carbon emission of tropical ecosystems and its potential role in REDD++ mechanism	Naishen Liang
14:00-14:15	WO006	Applying tunable diode laser spectroscopy for continuous measurement of methane flux at a forest canopy with a relaxed eddy accumulation method	Masahito Ueyama
14:15-14:30	WO012	Biogenic volatile organic compounds fluxes above larch forest measured using a relaxes eddy accumulation method	Tomoki Mochizuki
14:30-14:45	WO048	Biogenic volatile organic compound study from a temperate forest in Changbai Moutain	Jianhui Bai
14:45-15:00	WO034	Carbohydrate storage: Why do trees bother?	Philippe Thaler
15:00-15:15	WO052	Use of ecosystem flux data and a simulation model to examine seasonal drought effects on a subtropical coniferous forest	Mi Na
15:15-15:30	WO053	Impacts of tree plantations on carbon, water cycle and nutrient cycles: the case of rubber plantations in South East Asia	Frederic Gay
15:30-16:00		Discussion	
Closing Ceremony			

Poster Session

Poster presentation		
WP001	Co_2 exchange in Tropical Peat swamp forest in Sarawak, Malaysia	Kevin Kemudang Musin
WP002	Carbon balance of a logged over Tropical Peat swamp forest In Sarawak, Malaysia	Edward Baran Aeries
WP003	Meteorology variables in an Oil Palm plantation on Tropical Peatland	Deniel Sang
WP004	Seasonal characters of CO_2 flux above urban green space in Pearl River Delta, China	Chunlin Wang
WP007	Characteristics of temporal variations in ecosystem CO_2 exchange in a temperate deciduous needle-leaf forest in foothill of high mountain	Yoshiyuki Takahashi
WP008	Continuous soil CO_2 concentration measurements in Takayama supersite and their implications	Seiichiro Yonemura
WP015	Pattern in root respiration rates with their morphological traits in 13 tree species in tropical forest	Naoki Makita
WP027	Northern Japan's cool-temperate forest reaches a carbon compensation point 7 years after clear cutting	Maricar Morales Aguilos
WP028	Spatial and temporal distribution of light use efficiency in Chinese terrestrial ecosystem	Yanni Gao
WP030	The relation of drought and thermal stresses with inter-annual NDVI variability in dry land ecosystem	Nayoung Do
WP055	Long term monitoring of living and dead plant biomass in 50yearsold deciduous and evergreen forests	Yoshiko Wada
WP056	Preliminary study on long-term temperature trends between Mt. Ali and Mt. Jade, Taiwan	Yen-Jen Lai
WP011	Coupling a rectangular hyperbola model with dynamics of leaf area index to compute half-hourly canopy gross primary production rates of rain-fed maize	Jingsong Sun
WP019	Fluxpro as a quality control and quality assurance system for eddy covariance measurement	Wonsik Kim
WP020	A new gap-filling strategy for evapo-transpiration	Minseok Kang
WP031	In situ measurement of CO_2 efflux from leaf litter using automated chamber system	Mioko Ataka
WP069	The attenuation and correction for photosynthetically active radiation long-term observations with quantum sensor in China flux forest sites	Zhilin Zhu
WP038	Estimating of sensible heat and latent heat fluxes by coupling surface-layer scintillometer and eddy-covariance system over a forested hilly terrain	Chao-Jung Fan
WP052	Modeling soil respiration of tropical peat forest	Ryuichi Hirata
WP058	Developing a new diagnostically-approach for simulating terrestrial carbon cycle: integrating radiative transfer model to biosphere model	Takahiro Sasai
WP060	Detection of Irrigation timing and spatial distribution in the paddy rice fields considering land cover heterogeneity using MODIS images	Seungtaek Jeong
WP062	Comparison of conventional open-path and newly-designed close-path gas analyzers within a cloud forest in Taiwan	Hung Chih-Yuan

WP063	Simplified method of estimating photosynthetically active radiation from basic meteorological data	Yasuko Mizoguchi
WP018	Carbon budget of tropical forests in Southeast Asia and the effects of deforestation: an approach using a process-based model and field measurements	Minaco Adachi
WP021	Effect of excessive N supply on winter wheat productivity: an investigation over leaf, canopy, biomass, and yield levels	Fenghua Zhao
WP026	Effects of manure application on annual carbon budget at managed grassland in Japan	Shoji Matsuura
WP033	Stability in ecosystem carbon budget of rice paddy field based on long-term flux measurement	Akira Miyata
WP034	On delineating ecohydrologic process networks in gwangneung decidious forest	Juyeol Yun
WP041	Comparing CO_2 sink strength of two adjacent temperate forests in Korea	Bindu Malla Thakuri
WP043	Characteristics of dissolved carbon change in irrigation water	Yo Akaike
WP044	Impact of open burning and biomass decomposition on carbon budget in cropping field	Keisuke Yoshizawa
WP049	Diversity of carbon sequestration in managed and unmanaged broad leaved forest in Japan	Yuji Kominami
WP053	Water flow throughout stem-branch-leaf in co-dominant deciduous and evergreen trees	Kenichi Yoshimura
WP061	Leaf phenology in a tropical monsoonal evergreen forest at Sakaerat, Thailand, detected by fixed view camera images - influence of climate on the delay of green-up in 2009	Takahisa Maeda
WP067	Ecosystems carbon storage and carbon sequestration potential of two tree species on Inner Mongolia Plateau, China	Hao Yang
WP068	Comparison of coordinate rotation on fluctuant terrain	Guo Jianxia
WP005	Energy, water vapor, and CO_2 emissions from different urban land use in Sakai city	Yasuhiro Mitake
WP010	Effects of atmospheric ozone and co2 on isoprene emission from *Quercus* trees	Akira Tani
WP012	Wind tunnel experiment of turbulence at inside and outside of the canopy with limited length, and of flux measurement on inclined surface	Hiroaki Kondo
WP013	An analysis of canopy-scale relationship between photosynthesis and stomatal conductance in an irrigated rice paddy	Keisuke Ono
WP014	Continuous measurement of CH_4 emission from stream riparian zone in warm temperate deciduous forest	Takafumi Miyama
WP017	Measurements of methane flux in an evergreen coniferous forest using a relaxed eddy accumulation and chamber systems	Ayaka Sakabe
WP046	Partitioning of evapo-transpiration in a temperate grassland through isotopic measurements of H218o	Zhongmin Hu
WP022	Branch respiration research at the Chi-lan mountain site in Taiwan	Pei-ling Tsai
WP023	Nitrogen response efficiency of forest ecosystems in eastern china and its controls	Zhan Xiao Yun
WP024	Monitoring of soil respiration in rice and barley double cropping paddy-field in Gimje, Korea	Jaeseok Lee

WP025	Soil CO_2 efflux in a temperate deciduous forest: Environmental drivers such as soil temperature and soil water contents	Eunhye Lee
WP029	Plant root and shoot litter decomposition of dominant specie *leymus chinensis* in Hulunbeier meadow steppe	Cai Hong Zhang
WP037	Effects of tree species composition on soil respiration in deciduous and evergreen broad-leaved stands	Ryushi Sasaki
WP042	The quantification of the methane flux from a paddy field	Atsuhiro Kunishio
WP045	Soil respiration of five forest types and their relations in subtropical China	Yidong Wang
WP051	Heterotrophic respiration in warm- and cool-temperate broad-leaved forests in Japan	Mayuko Jomura
WP054	Linking natural and social fluxes	Takashi Machimura
WP059	Urban flux and other micrometeorological applications of the Picarro g2311-f methane, carbon dioxide, and water vapor analyzer	Gloria Jacobson
WP065	Summer evapo-transpiration based on multi-year observations including extreme climatic conditions over a cool-temperate evergreen coniferous forest, Takayama, Japan	Taku M Saitoh
WP009	The effect of patchy stomatal behavior on leaf- and canopy-scale CO_2 flux of a tropical rainforest in Peninsular Malaysia, Pasoh	Mai Kamakura
WP016	Measurement of autotrophic respiration of tree in Pasoh -from leaves to roots	Masako Dannoura
WP036	Biogenic volatile organic compound emissions from thirty eight tropical tree species in Malaysia	Motonori Okumura
WP039	Vertical profile of leaf photosynthetic characteristics in a tropical lowland *Dipterocarp* forest at Pasoh, Peninsular Malaysia	Satoru Takanashi
WP040	Relationship between LUE and tower-observed spectral vegetation indices in a tropical rainforest at Pasoh, Peninsular Malaysia	Tatsuro Nakaji
WP050	Inter-site comparison of ecosystem physiological parameters of Asian forest	Kentaro Takagi
WP066	Footprint for carbon dioxide flux in several sites of FFPRI Fluxnet	Katsumi Yamanoi
WP048	Underestimated effects of low temperature during early growing season on carbon sequestration of a subtropical coniferous plantation	Wenjiang Zhang

Oral Session

TROPICAL PEATLAND & GREENHOUSE GAS EMISSION

Lulie Melling

Tropical Peat Research Laboratory Unit (Chief Minister's Department),
Jalan Badruddin, 93400 Kuching, Sarawak, Malaysia

Tropical peatland is the **last frontier of arable land** available for industrial agricultural development in Sarawak. Being the last exploited land resources, it is the least researched soil type among the tropical soils and thus the least understood. Tropical peat has been considered a fragile ecosystem and an important, essential carbon storage. Recently, there has been an increase in oil palm cultivations on tropical peat. Oil palm is now a very important strategic and international commodity which plays a very significant role in the world vegetable oil market. It is also the most productive and affordable vegetable oil today. Cultivation of oil palm in Sarawak is both for socio-economic development and export earnings and this makes oil palm a very important "**National Economic Security Crop**". Tropical peats are liken to mineral soils of the tropics and are quite different from temperate peats because they are formed under contrasting climatic and edaphic conditions. Temperate peats are mainly derived from the remains of low growing plants (*Sphagnum* spp., *Gramineae* spp. and *Cyperaceae* spp.). Tropical peats, on the other hand, are formed from forest species and hence tend to have large amounts of undecomposed and partially decomposed logs, branches and other plant remains. Drainage, compaction and water management form part of the development processes for oil palm planting on peat. This management process has been claimed to increase greenhouse gas emissions (GHG) from land use change on tropical peatland and has received increasing attention in determining the climate change effect of peatland conversion. To understand further both the carbon and nitrogen dynamics of peatlands, more data is needed to determine its carbon balance. A full ecosystem carbon balance for different landuse types on tropical peatland can be estimated quite precisely with the use of Eddy Covariance (EC) Flux measurements. These measurements need to be complemented with closed chamber method because EC only provides a spatial average of GHG emissions from within the flux footprint, and does not provide information on small scale processes operating at lower spatial scales, which would lead to erroneous conclusions where emissions "hot spots" exist. Thus, in order to develop a proper and scientific understanding on the effect of landuse change on greenhouse gas emission from tropical peatland, three (3) eddy covariance flux measurements has now been commissioned in a peat swamp forests, logged over forest and an oil palm plantation.

EFFECTS LAND SURFACE TYPE, LAND USE, AND LAND USE CHANGE ON AQUATIC-ATMOSPHERE FLUXES OF CO_2 FROM TROPICAL FORESTS AND PEAT LANDS OF BORNEO

W. Oechel[1], G. Anshari, O. Abelleira, H. Ikawa, W. Lawrence, M. Metz, M. Neteler, D. Rocchini, Donatella Zona

[1]Global Change Research Group, San Diego State University

Tropical peat lands appear to be loosing huge amounts of CO_2 to the atmosphere due to patterns of land use and land use change including conversion of tropical forest peat lands to palm oil production and other agricultural endeavors and forest exploitation. Here, we look at the effect of land use patterns on the export of carbon to tropical river systems and the efflux from tropical rivers to the atmosphere. Levels of DOC and POC were measured in the Kapuas River, the longest river in Borneo. Patterns of land use and land use change were correlated with export rates of organic matter to the river as well as the vertical fluxes of CO_2 from the river and delta to the atmosphere. Land conversion of tropical forests on peat land soils to agriculture, including palm oil production, had some of the highest rates of lateral fluxes of organic carbon to the river system, and among the highest fluxes of CO_2 from the river to the atmosphere. This approach illustrates the utility of using a combination of methods: pCO_2 measurement, boat based eddy covariance, water chemistry, temporal remote sensing, and modeling to understand and quantify the impact of land use change on GHG emissions from tropical peat lands.

INFLUENCE OF EL NIÑO / LA NIÑA EVENTS (2008-2010) ON ECOSYSTEM CO_2 EXCHANGE IN FLOODED AND NON-FLOODED RICE FIELDS IN THE PHILIPPINES

M.C.R. Alberto[1], R.Wassmann[1,2], T. Hirano[3] and A. Miyata[4]

[1]*International Rice Research Institute, Los Baños, 4031 Laguna, Philippines*
[2] *working as GTZ/CIM integrated expert on temporary leave from Karlsruhe Institute of Technology, Germany*
[3] *Research Faculty of Agriculture, Hokkaido University, Japan*
[4] *National Institute of Agro-Environmental Sciences, Tsukuba, Japan*

The seasonal and interannual variation in CO_2 fluxes measured by the eddy covariance method was examined during the ENSO events (2008-2010). We assessed the effects of the El Niño / La Niña events on the seasonal climate conditions and determined how it affected the ecosystem CO_2 exchange of two contrasting rice environments: flooded and non-flooded. We also investigated the key environmental and biological factors affecting the ecosystem respiration (*Re*) and gross primary production (GPP) and net ecosystem CO_2 exchange (NEE) of the two rice ecosystems.

The 2008 dry season (DS) was under a La Niña event while the 2008 wet season (WS) was a neutral one with strong typhoons associated during the wet season. The 2009DS was also La Niña while the 2009WS was El Niño; however, the northern part of the Philippines experienced strong tropical typhoons. The 2010DS was under an El Niño event while the 2010WS was another La Niña. In the Philippines, El Niño frequently contributes to reduced rainfall and drought while La Niña results in excessive rainfalls, floods and more intense typhoons in many areas. The net C uptake in flooded rice field was higher than in non-flooded field in all cropping seasons. Both flooded and non-flooded rice fields had lower net C uptake in 2008DS (-164 and -14 g C m^{-2}, respectively) than in 2008WS (-295 and -82 g C m^{-2}, respectively) because the La Niña event during 2008DS resulted to low solar radiation and this climate anomaly decreased the GPP in both fields. The net C uptake was highest in 2009DS in both flooded and non-flooded rice fields (-351 and -218 g C m^{-2}, respectively) because of the cooler and wetter climate brought by the 2009 La Niña event. This climate anomaly resulted to lower *Re* in both fields as well as higher GPP in non-flooded field since the climate was favorable for the growth of the aerobic rice, the ratoon crops and the weeds. The NEE decreased in 2009WS in both flooded and non-flooded rice fields (-225 and -39 g C m^{-2}, respectively) due to the devastating effects of the strong typhoons that hit the Philippines in the wet season. However, in 2010DS, the net C uptakes of flooded and non-flooded rice fields were closely similar at -187 and -174 g C m^{-2}, respectively. This shows the advantage of the aerobic rice over the flooded rice during El Niño events.

For our study sites, the key environmental and biological factors affecting GPP were photosynthetically active radiation (PAR) and leaf area index (LAI) while *Re* was controlled by air temperature, LAI and plant biomass. The GPP in flooded rice was substantially larger than in aerobic rice; the difference was likely related to the greater photosynthetic capacity and a more rapid accumulation of green leaf area of flooded rice plants. The flooded rice field had significantly lower *Re* ($\rho = 0.05$) than non-flooded field only when LAI was below 5 m^2 m^{-2} because at the latter growth stage, *Re* of flooded field was enhanced due to larger plant biomass and higher LAI. The *Re* of flooded rice field was more sensitive to increase in air temperature than non-flooded field as shown by their higher Q_{10} values. The NEE of flooded rice field was also more sensitive to increase in vapor pressure deficit than non-flooded field. This shows the tolerance response of aerobic rice to drought stress.

MODELING ECOHYDROLOGICAL CONTROLS ON ECOSYSTEM NET CO_2 EXCHANGE OF A TROPICAL BOG

Symon Mezbahuddin[1], Robert Grant[1] and Takashi Hirano[2]

[1]*Department of Renewable Resources, University of Alberta, AB, Canada*
[2]*Research Faculty of Agriculture, Hokkaido University, Sapporo, Japan*

Hydrology is one of the key controls governing peatland carbon balance under current and future climatic conditions.Seasonal variations in soil water content and water table depths can alterthe balance between peatland primary production and respiration and socause a peatland to changebetweena sink and a large source of carbon. Seasonal and interannual variation in peat hydrology can affect primary production and respiration through its influence on evapotranspiration, plant water and nutrient uptake and on microbial decomposition. Simulatingecohydrological controls on current and future net ecosystem productivity (*NEP*) of peatlands thus demandsmodels with coupled soil-plant-atmosphere schemes for gases, water, energy, carbon and nutrients (N, P). We combined a 3-dimensional water transport scheme and internal water table dynamics with an existing ecosystem model *ecosys* in order to examine the hydrological controls on seasonal and interannual variability in*NEP*of the PalangKaraya Peat Swamp forest, Indonesia. Simulated hourly ecosystem energy and CO_2 fluxes along with hourly near surface soil water content and daily water table depths correlated very well (R^2~ 0.80) with measurementsat the site during 2002-2005. We compared hourly modeled and measuredfluxesduring the rainy season, the wet-dry transition and the dry seasonin two years with contrasting rainfall in order to see how water table fluctuations altered the diurnal and seasonal patterns of *NEP*. During the rainy season, shallower rooting caused by near-surface water tables and consequent inadequate aeration slowed water and nutrient uptake,which reduced *GPP* and hence*NEP* so that the peatland remained a net C source. During thewet-dry transition, intermediate water tables stimulated *GPP* through deeper rooting and hence more rapid plant water and nutrient uptake, and also*RE*by enhancing aerobic decomposition. This increase in *GPP*was greater than that in *RE*sothat*NEP*rose, allowing the peatland to become a small C sink. During the later dry season, however, deeper water tables caused near-surface soil drying and hence lower soil and canopy water potentials which decreased stomatalconductances and hence *GPP*. Though near-surface drying slightly reduced near surface peat decomposition, this reduction was eventually offset by more rapid decomposition in deeper peat layers so thattotal*RE*increased.This increase caused *NEP*simulated and measured during the later dry season to decline sharply, causing the peatland to become a large C source. Seasonal changes in *GPP*, *RE* and *NEP*differed between the drier and the wetter year. The drier year showed a smaller decrease in *GPP* during the rainy season and a larger decrease in *GPP*and increase in *RE* during the dry season with respect to those of the wetter year, so thatannaul*NEP* measured (-602 g C m^{-2} y^{-1}) and modelled(-450 g C m^{-2} y^{-1}) during the drier yeardeclined from that duringthe wetter year (measured -313 and modeled -178 g C m^{-2} y^{-1}). These changes in seasonal and annual CO_2 exchange can be simulated with models that represent basic processes for soil-plant-atmosphere transfers of gases, water and energy. Such models can provide a predictive capability for how peatland productivity might change with hydrology under future climates.

MODELING ECOHYDROLOGICAL CONTROLS ON PLANT WATER RELATIONS AND ECOSYSTEM ENERGY BALANCE OF A TROPICAL BOG

Symon Mezbahuddin[1], Robert Grant[1] and Takashi Hirano[2]

[1]Department of Renewable Resources, University of Alberta, AB, Canada
[2]Research Faculty of Agriculture, Hokkaido University, Sapporo, Japan

The response of peatland evapotranspiration to changes in water table depth has been reported to vary widely, suggesting complex controls on peatlandecohydrology.Water table dynamics, peat moisture retention characteristics and rooting depthof the peat-forming vegetation are three key controlsthought to causevariationinthis response across different peatlands.Causes of this variation may be examined with mathematical models that simulatediurnal, seasonal and interannual changes in ecosystem water and energy balances.Such models needcoupled schemes for i) vertical and a lateral water transportto model internal water table dynamics, includingmacropore flow to simulate rapid near-surface drainage and associated sudden drops in soil moisture content shortly after heavy rainfall events, and ii) soil-plant-atmosphere water transport that accounts for rooting depth and density, root water uptake, transpiration demand and stomatal behavior of peatland vegetation. In the present study we used the hourly process model *ecosys*, in which these coupled schemes are represented in detail, to examine the magnitude and patterns of ecohydrological controls on seasonal and interannualvariationin water and energy balances of the PalangKaraya Peat Swamp forest.Hourly soil water contents, water table depthsand energy fluxes simulated at this site were in close agreement with those measuredunder differing rainfall during 2002-2005 (R^2 ~ 0.80), thus indicating that the model could simulate diurnal, seasonal and interannual courses of water and energy balancesof this forest. We then usedthe model to explain how seasonal and interannualvariationin water table depths affected peatland evapotranspiration. During the rainy season, shallow water tablesreducedmodelledrooting depth and density throughinadequateaeration,raising root resistances,lowering canopy water potentials and stomatalconductances, and hence raising Bowen ratios (*H/LE*) (~ 0.4). At the onset of the dry season, receding water tables allowed greatermodelled rooting depth and density and consequent more rapid root water uptake whichlowered Bowen ratiosfromthose during the rainy season(~0.2). During the later part of the dry season when water tables werelowest, decreases in soil water potentials of near surface peat layers caused decreases in root and canopy water potentials and hence in stomatalconductances, thereby increasing Bowen ratios(~ 0.6). Though there was available water in the deeper peat layers even in the late dry season, slow capillary rise due to high macroporosity failed to replenish water removed by root uptake.These changes in Bowen ratios during the rainy season, and the early and late dry seasonswere not similar in all years. Ina drier year, water tablesduring the rainy seasonweredeeperso that Bowen ratios remained lowerthan those in a wetter year. However water tables during the dry season were alsodeeper, so that Bowen ratios rose further than did those in a wetter year. Our study indicatesthatmodelsused to study seasonal and interannual variations inpeatland water and energy balancesneed these coupled schemes in which basic processes for soil and soil-plant-atmosphere water transport are represented. Such models create new opportunities to project how climate change might impact the water and energy balance of particularly vulnerable peatland ecosystems.

QUANTIFY BIOSPHERE-ATMOSPHERE INTERACTIONS IN AN ESTUARIAL GRASS MARSH ECOSYSTEM BY USING EDDY-COVARIANCE TECHNIQUE

Jehn-Yih Juang[1], Chao-Jung Fan[1], Tzi-Yi Wu[1] and Shih-Bin Ding[1]

[1]*Department of Geography, National Taiwan University, Taipei, Taiwan*

In the past decades, the eddy-covariance technique has been widely applied to quantify the biosphere-atmosphere interactions in many flux observation sites. However, most of the sites are located in forest ecosystem because forests are known play the most important role on terrestrial carbon cycling in many regions. Although many studies have address that the estuarial ecosystems located in the tidal zone are very important for nutrient cycles between the terrestrial environment and the ocean, very few attentions are given to exploring such exchanges by using eddy-covariance towers.

In this study, a flux monitoring tower using eddy-covariance technique in a grass marsh ecosystem close to downtown Taipei was established to systematically investigate the interactions among the ecosystem, the atmosphere, and the environment. The flux tower was initiated in the spring of 2011. It is located in the west part of Guandu Natural Park in northwest Taipei City (25°7'N, 121°28'E; 4 m a.s.l.). This is a grassland ecosystem in a tidal zone; predominant species are para grass (*Brachiariamutica*) and common reed (*Phragmitesaustralis*). Because the study site is located only 10 km away from the estuary of Danshui River and on the transition zone between the urban and suburban areas, the influences of the estuarial tides and human activities are expected to play important roles on the biogeochemical cycles in this study site.

The main objective of this study is trying to integrate the background information (meteorological, hydrological, and environmental forcing), and eddy-covariance measurement data to investigate the interaction of biological components and their environmental factors. In addition, this study is planning to characterize and quantify the impact of different disturbances, such as weather system (typhoons, fronts), flooding, and human activities, on the functional and structural components of the grass marsh ecosystem in this study area.

ECOSYSTEM WATER USE EFFICIENCY FOR A REED MARSH IN LIAOHE DELTA, CHINA

Li Zhou[1, 2], Guangsheng Zhou[1, 2] and Yu Wang[2]

[1]Chinese Academy of Meteorological Sciences, Beijing 100081, China
[1] State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing 100093, China

Ecosystem water use efficiency (WUE) is a quantitative index indicating the coupling relationship between ecosystem carbon and water vapour fluxes. Studies on variations and regulations of WUE at the ecosystem level are essential for better understanding and predicting ecosystem responses to climate change. We made continuous measurements of carbon dioxide and water vapor fluxes over a reed marsh in the Liaohe Delta, China, by using the eddy covariance technique. These measurements allow the calculations of gross ecosystem productivity (GEP), evaportranspiration (ET) and WUE. With contemporary micrometeorology data and leaf area index (LAI), variations and regulations of WUE were analyzed at differential temporal scales.

The results show that the average annual WUE at the reed marsh was 8.62 ± 0.44 g CO_2 kg^{-1} H_2O during the study period. Ecosystem WUE changed diurnally and seasonally. The seasonal variation of WUE was similar with those of GEP and ET, while it resulted mainly from the fluctuations of GEP, and GEP could explain about 62% of the variation ($p<0.001$). The factors controlling seasonal variation of ecosystem WUE were temperature (Ta), vapour pressure deficit (VPD) and LAI. Among them, WUE had positive relationship with Ta and LAI, and negative relationship with VPD. Daily variation of ecosystem WUE over the reed marsh showed U curve pattern. The daily variation of WUE was controlled by soil temperature (Ts), VPD and PAR. Among them, WUE had a positive relationship with Ts, and a negative relationship with VPD and PAR.

CARBON STORAGE OF CAIMPUGAN PEATLAND IN AGUSAN MARSH, PHILIPPINES: ITS ROLE IN GREENHOUSE GAS MITIGATION AND ANALYSIS OF ITS ECOSYSTEM THREATS

Van Leeah B. Alibo

Caraga State University, Butuan City, Philippines

Globally, peatlands are considered to have a high potential in mitigating climate change, but no study has been done in the Philippines. This study estimated the amount of stored C in the Caimpuganpeatland, which is one of the seven vegetation types that characterize the Agusan Marsh in Northeast Mindanao and analyzed the environmental disturbances that threaten the integrity of the peatland primarily in its role in mitigating greenhouse gas emissions.

Integrative environmental methodologies were used. The aboveground C stocks were measured in standing trees, understorey and herbaceous vegetation and litter and belowground C stocks in peat soils at different horizons of Tall Pole Forest, Intermediate Forest and the Pygmy Forest covers in two locations within the peatland. Non-destructive sampling was done for trees > 5 cm dbh using allometric equations (Brown, 1997). The carbon contents of the understorey and herbaceous vegetations and litters were estimated by multiplying oven dried biomass by 45%. Total soil organic carbon was determined using Flash Elemental Analyzer 1112 Series Carbon Analyzer. A two way ANOVA was used to compare estimated stored C among selected vegetation types with location as the replication. Ecosystem threats were assessed using the Driver-Pressure-State-Impact-Response (DPSIR) Framework.

The Caimpuganpeatland was found to be a substantial and space efficient C store compared to other forest types in the country. The estimated aboveground C stock of Caimpuganpeatland in Agusan Marsh was 22.8 million tons of C within its 5, 487 hectare peatlandwith an estimated > 3,000-6,000 tons of C on a per hectare basis. The estimated mean belowground C stock (4,659.06 tC/ha) was much higher than the mean aboveground C stock (52.53 tC/ha). The findings have identified that the most important C pool in the system is the peat soil since its C storage estimates are exceptionally higher than any of the aboveground C pools combined.

Analysis of ecosystem threats through the Driver-Pressure-State-Impact-Response (DPSIR) framework revealed that the peatland is at a considerably alarming level of degradation. Anthropogenic disturbances were more dominant than the natural factors that threaten the sustainability of ecosystem service on C sequestration. Threats and consequences of disturbance are though considered manageable as of present time as long as strict implementation of existing ordinances are maintained. Although natural uncertainties could serve as potential threats to keeping the integrity of the peatland as a C sink, the social and institutional aspects remain to be controllable, and hence, stands elemental in the configuration of Caimpugan peatland as a C sink. This establishes the need and the urgency to mold an informed and empowered body of stakeholders from the decision makers, resource managers, and policy makers for the actual enactment of current and future efforts aimed for the protection and consrervation of the Caimpugan peatland.

ESTIMATING NET PRIMARY PRODUCTIVITY OF MALAYSIA FOREST: AN ANALYSIS USING SATELLITE DATA

Ab. Latif Ibrahim

Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia
81310 UTM, Johor Bahru Malaysia

Net primary productivity (NPP) refers to the net flux of carbon from the atmosphere into green plants per unit time. It is defined as the difference between total carbon uptake through photosynthesis and losses (through maintenance or growth respiration). NPP is the fundamental process in the biosphere functioning and is needed for assessing the carbon balance at regional and global scale. The knowledge of NPP distribution provides information on the productivity of croplands, forest and grasslands and thus helps improve management strategies for sustainable development of natural resources. Various models have been developed for the estimation of NPP and NPP is considered as one of the most-modeled ecological process. However the differences in term of approaches and complexity of most models have often yield comparable estimates of NPP values. In the contact of Malaysia forest, the quantity and spatial distribution of NPP both seasonal and temporal are not well understood. The used of various satellite remote sensing data which has become the most preferred technique for estimating global NPP will be very useful in understanding forest NPP of Malaysia, especially aspects related to its quantum, spatial variability, and distribution across seasons. In this study, analysis were carried out using three types of satellite data NOAA AVHRR, MODIS and Landsat-TM.

THE RECCAP/APN SOUTH AND SOUTHEAST ASIAN GREENHOUSE GASES BUDGETS

Prabir K. Patra[1], Josep G. Canadell and potential contributors

[1]*Research Institute for Global Change, JAMSTEC, Kanagawa, Japan.*

Since last year (2010) we have been coordinating an international effort to estimate the regional carbon sources and sinks from the South and Southeast Asia regions under the REgional Carbon Cycle Assessment and Processes (RECCAP - http://www.globalcarbonproject.org/reccap). The focus on these two regions is because they are among the least studied regions compared to other well-developed study regions such as the Europe and the North America In view of this, we have launched an effort under the Asia Pacific Network (APN) estimate carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) sources and sinks using the state-of-the-art models and available observational data. We plan to advance our knowledge by synthesizing available observations, running regional model applications, and collecting new data. We have now access to results from seven terrestrial ecosystem models (TRENDY project) and 12 atmospheric inverse models (TransCom project). The results show large variations, mainly due to the lack of regional validation and parameterization of the models. However, large amount of data are collected by the AsiaFlux and the aircraft by Japan AirLines (JAL) CONTRAIL and Lufthansa CARIBIC projects. The latter data are being used for constraining and validating inverse model results very recently. However, the process level understanding on the dynamics of ecosystem uptake and release of greenhouse gases is lacking, and likewise the constraints for terrestrial models and regional flux products are very limited. We believe that AsiaFlux can have a relevant contribution to establishment of large scale regional GHG budgets by covering many of the above described gaps.

We look forward to a close collaboration between the RECCAP/APN and AsiaFlux for the production of robust estimates of regional sources and sink of greenhouse gases.

MONITORING PADDY FIELD CARBON AND EVAPOTRANSPIRATION FLUXES USING FIELDHYPERSPECTRAL REFLECTANCE MEASUREMENTS - AN EXPERIMENTAL STUDY IN NORTHERNTAIWAN

Ke-Sheng Cheng[1], Cheng-I Hsieh[1], Ying-Syuan Chen[1] and Yun-Chieh Wang[1]

[1]Department of Bioenvironmental Systems Engineering, National Taiwan University Taipei, Taiwan, R.O.C.

In this study field measurements and Landsat-7ETM satellite images were used to estimate the two-scale paddy field parameters in the growth period of rice, and to investigate the relationships between the vegetation indices and the carbon dioxide fluxes. FAPAR was estimated using an algorithm developed by Gobron (2005) and the Monteith light use efficiency model was used to estimate NPP. Empirical relationships between NDVI, FAPAR, NPP and CO2 flux were established. It was found that NPP is more sensitive than NDVI and FAPAR. Such results are consistent with Zhao (2006) that NPP is the primary driver of the atmospheric CO2 growth rate. Three methods of evapotranspiration (ET) estimation, namely the FAO-56 Penman-Monteith method, eddy covariance method, and remote sensing method using Landsat ETM+ , were also used to estimate ET flux of a paddy field. The results of FAO-56 and using Landsat ETM+ are similar to previous studies and different from eddy covariance. The results demonstrate the potential of using multispectral images to estimation of ET of rice paddy field.

Keywords: Normalized difference vegetation index (NDVI), fraction of absorbed photosynthetically active radiation (FAPAR), net primary production (NPP), CO2 flux, evapotranspiration, remote sensing.

VALIDATION AND IMPROVEMENT OF MODIS GROSS PRIMARY PRODUCTIVITY IN TYPICAL FOREST ECOSYSTEMS OF EAST ASIA

Yanlian Zhou[1], Mingzhu He[2] and Weimin Ju[2]

[1] School of Geographic and Oceanographic Sciences, NanjingUniversity, Nanjing, China
[2] International Institute for earth system science, NanjingUniversity, Nanjing, China

As a key component of terrestrial carbon cycle, gross primary productivity (GPP) is a major determinant of carbon exchange between the atmosphere and terrestrial ecosystems. 8-day global MODIS GPP provides a potential for carbon cycle research at global or regional scales. Many previous studies indicated that MODIS GPP has large uncertainties. And the error of MODIS GPP simulation was partly caused by biases in meteorological data inputs, including VPD, air temperature, and photosynthetically active radiation (PAR), and the value of Maximum light use efficiency (ε_{max}).

GPP in six typical forest ecosystems of East Asia was simulated with unbiased observed meteorological data and optimized ε_{max} by using MOD 17 algorithm. The results indicated that unbiased observed meteorological data and optimized ε_{max} improved the accuracy of GPP simulation greatly.

However, there were still obvious bias between GPP derived from eddy covariance and simulated MODIS GPP. And higher values of GPP were over estimated, while lower values of GPP were under estimated. With this question in mind, photosynthetically active radiation absorbed by the canopy was calculated by separating the sunlit and shaded leaf groups. The results showed that with this improved photosynthetically active radiation, modeled GPP shows a good agreement with GPP derived from eddy covariance.

Key words: Gross Primary Productivity, MODIS, the sunlit leaf, shaded leaf, Forest ecosystem

IMPACTS OF CLIMATE CHANGE ON ECOSYSTEMS IN JEJU ISLAND, KOREA

Gwangyong Choi

Major of Geography Education, Jeju National University, Jeju-si, Jeju Self-Governing Province, Republic of Korea

The elevation (1,950m) of HanlaMountain in the center of JejuIsland provides versatile ecosystems on a volcanic island in a subtropical climate. In this study, changes in temperature and precipitation and their associations with changes in phenology and vertical distribution of temperate and subalpine ecosystems on HanlaMountain are examined based on observed and modeled data. Fieldwork observations suggest that the habitats of temperate species such as *Pinusdensiflora*have spread toward subalpine ecosystem zones and that those of subalpine species such as *Abieskoreana*have retreated toward higher elevation zones with increasing mortality. Both observed (Automatic Weather Station; AWS) and remotely sensed (MODerate-resolution Imaging Spectroradiometer; MODIS imagery) data consistently show that in the 2010s, the growing seasons have continued for approximately eight months in subalpine ecosystem zones of Hanla Mountain. Modeled(Korea Meteorological Administration's Regional Climate Model; KMA RCM) climatic data project that the growing season length will increase by two months in the 2090s. A threefold increase in summer days (Tmax≥25℃) and a disappearance of the 30 day ice (Tmax≤0℃) period are also projected for the present-day subalpine zones of HanlaMountain. These results suggest that the highland subalpine ecosystem in lower mid-latitude regions may face extinction due to frequent occurrences of adverse warm events in the warmer 21st century and the incursion of temperate species.

Keywords: subalpine ecosystem, subtropical climate zone, climate change, HanlaMountain.

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RELATIONSHIP BETWEEN CLOUDS, RADIATION AND CANOPYPRODUCTIVITY IN SAVANNAS

Kasturi Devi Kanniah[1], Jason Beringer[2], and Lindsay Hutley[3]

[1] Department of Remote Sensing, University of Technology Malaysia, 81310, Skudai, Johor, Malaysia
[2]School of Geography and Environmental Science, Monash University, Clayton, Vic 3800, Australia.
[3] Research Institute for the Environment and Livelihhods, Charles Darwin University, Darwin, NT 0909, Australia.

Clouds can significantly affect carbon uptake of savannas by controlling the incoming solar radiation. In this study,we integrated in situ measurements with eddy covariance based flux tower data to analyse the control of clouds (important environmental variables in savannas) on the temporal variation of gross primary productivity (GPP) at Howard Springs, a tropical savanna site in northern Australia. Data on clouds and radiation measured at the Atmospheric Radiation Measurement (ARM) site at the Darwin airport were used to explore the link between radiation, aerosols, clouds and GPP measured at a nearby eddy flux site in Howard Springs (20 km from ARM site). We employed a rectangular hyperbola model and other statistical techniques to achieve the objective of the study. Results indicated that clouds affected the temporal variability of savanna productivity by altering the quantity and quality (partitioning of total radiation into direct and diffuse) of solar radiation. It was found that in the wet season, diffuse radiation increased due to cloudiness but was overshadowed by large decreases in total radiation. Thick clouds inthe wet season produced much morediffuse radiation, which caused increases in canopy quantum efficiency by 26% and 17% under thick and thin clouds,respectively, compared to clear sky conditions. This is consistent with higher daytime LUEand WUE under thick clouds. However, the enhanced LUE under cloudy skies comparedto clear skies is insufficient to increase GPP due to the dramatic decline in total radiationwhen clouds shade the surface. Reduction in total radiation (57% under thick clouds compared to clear sky periods) due to clouds decreased themean absolute GPP by 19% under thick clouds, comparedto clear sky conditions.The observed effect of cloudson GPP is reported for the first time for Australian savannas. Results from this study suggest that reducedcloud cover may increase GPP, and hence the carbon sequestrationpotential of this ecosystem.

ADVANTAGES OF FAST MIXING RATIO ESTIMATION IN AN ENCLOSED GAS ANALYZER

James Kathilankal[1] , George Burba[1], Andres Schmidt[2], Russell L Scott[3], Taro Nakai[4], Gerardo Fratini[1], Chad Hanson[2], Beverly Law[2], Dayle K McDermitt[1], Robert Eckles[1], Michael Furtaw[1], and Michael Velgersdyk[1]

[1] LI-COR Biosciences, 4421 Superior Street, Lincoln, NE68504, USA
[2]College of Forestry, OregonStateUniversity, 328 Richardson Hall, Corvallis, OR97331, USA
[3] Agricultural Research Service, USDA, 2000 E. Allen Road, Tucson, AZ85719, USA
[4] International Arctic Research Center, University of Alaska, 930 Koyukuk Drive, Fairbanks, AK99775, USA

Open and closed path gas analyzers have been traditionally used for understanding the ecosystem level exchange of carbon dioxide (CO_2) and water vapor (H_2O). An enclosed gas analyzer design was developed to maximize the strengths and minimize weaknesses of traditional designs. An important feature of this design is the ability to output instantaneous mixing ratio or dry mole fraction, which is made possible by the fast pressure and temperature measurements inside the sampling path. Dry mole fractions account for the thermal expansion and contraction and water vapor dilution thus avoiding the need density corrections. This concept of calculating fluxes using instantaneous mixing ratio was tested in nine field experiments in 2009-2010 in a wide range of ecosystems and setups. The fluxes calculated using fast mixing ratio without any density correction compared well with the fluxes calculated from molar density estimates with suitable density corrections. This has important implications for future flux measurements, because avoiding hourly density corrections could bring the advantages of increasing flux measurement quality and temporal resolution, reducing the magnitude of minimum detectable flux, unifying data processing steps, and assuring better inter-comparison between different sites and networks. Like the closed-path analyzer, the enclosed design leads to minimal data loss during precipitation events and icing, and it does not have surface heating issues. Like the open-path design, the enclosed design has good frequency response due to small flux attenuation loss in the short intake tube, does not need frequent calibration, has minimal maintenance requirements, and can be used in a very low power configuration.

THE IMPACT OF CHANGES IN BAROMETRICPRESSURE ON LANDFILL METHANE EMISSION

Liukang Xu[1], Jim Amen[1], Xiamao Lin[1], and Karla Welding[2]

[1]LI-COR Biosciences, Lincoln NE 68504 USA
[2]City of Lincoln, Lancaster County, NE 68517 USA

On a global scale, landfill methane emissions contribute over 15% of the anthropogenic methane burden into the atmosphere. Quantitative understanding of methane emission from landfills and how environmental variables regulate the emission is essential for; (1) modeling studies, (2) determining the mitigation strategy, and (3) for formulating controls and regulations by appropriate agencies.Here we present results from a recent study on the relationship between landfill methane emission and changes in barometric pressure. We used the eddy covariance method to continuously monitormethane flux and barometric pressure at Bluff Road Landfill near Lincoln, Nebraskafrom June to December, 2010. Our results show that the methane emission rate is strongly dependent on atmospheric pressure changes; i.e., rising atmospheric pressure suppresses the emission, while falling atmospheric pressure enhances the emission. We found that the phase angle between methane flux and barometric pressure to be around 180^{o} on a weekly time scale. From our study, 6-day continuous emission measurements in warm seasons are needed to average out the impact of barometric pressure changes on landfill methane emissions. Much longer times (~10 days) are needed in cold seasons because of its stronger weather systems (in terms of duration and magnitude of pressure changes) as compared with those in the warm season. Our results also show that there are few seasonal variations in landfill methane emissions after the impact of changes in barometric pressure on the emissions are averaged out. This seems to suggest that the amount of methane that was kept inside the landfill during the time of rising barometric pressure probably diffused into the atmosphere during the time of falling pressure, and didn't get lost via oxidation. The winter methane emission rate was found to be slightly higher than that in summer, presumably because of a low oxidation rate. Our results indicated that short time interval measurements with techniques such as the trace plume method, mass balance method, or closed-chamber method will have large variations in measured emission rates because of the strong dependence of methane emissions on atmospheric pressure changes. Estimates of annual total landfill methane emissions based on those measurements will inevitably yield a large uncertainty, up to a factor of ten. A similar relationship between methane emission and changes in barometric pressure has been observed and reported from many studies over peatland, wetland and other ecosystems. Our results demonstrate that it is imperative to make continuous methane emission measurements over landfill, wetland and other ecosystem in order to correctly estimate the total methane emission.

HUMIDITY CORRECTION FOR TRACE GAS FLUX BY CHAMBER MEASUREMENTS

Y. Harazono[1,4], H. Iwata[1], K. Takahashi[2], A. Sakabe[3], M. Ueyama[4], and Y. Kosugi[3]

[1]*International Arctic Research Center, Univ. of Alaska Fairbanks, Fairbanks, USA.*
[2]*Research Institute for Sustainable Humanosphere, Kyoto University, Uji, Kyoto, Japan*
[3]*Graduate School of Agriculture, KyotoUniversity, Kyoto, Japan*
[4] *Life and Environmental Sciences, Osaka Prefecture University, Sakai, Osaka, Japan*

Most trace gas fluxes have been previously measured by chamber techniques owing to the sensitivity limitation of analyzer. While, the recent advances in laser spectroscopy allow us to measure several trace gases simultaneously, such as methane, carbon dioxide, nitrous oxide, and water vapor with adequate resolution. Also some analyzers can provide the measurements at fast sampling rates for the application of eddy correlation technique. Applications of newly developed analyzers have been providing interesting and improved flux evaluations comparing to the previously obtained results. One important issue is the dilution effect by water vapor on flux evaluation.

Flux observations by chamber techniques have seldom concerned about the humidity change during the measuring period, because it was quite difficult to detect the small changes in water vapor in parallel with trace gas changes. Therefore, some measurements happen to include uncertainty caused by dilution of changed water vapor by evapo-transpiration within the chamber. For example, a result of methane concentration of closed-type chamber on Japanese cypress foliage, measured by a TDLS-analyzer (RMT-200, LGR, Mountain View), showed clear decreasing trends, namely apparent CH_4-sink fluxes of the foliage. However, water vapor contents increased parallel by transpiration, so that the measured CH_4 decreasing trend was due to dilution by transpired water vapor inside the closed-chamber. The transpired water accumulated within the closed chamber during the measurement.

We applied multi-sensor type of TDLS-analyzer (GGA907-0010, LGR, Mountain View) for two dynamic chambers over tundra, to examine the dilution effect on CH_4 flux measurements. We assumed that the dilution effect of dynamic chamber might be little comparing to that for closed chamber, because the residence time of air-flow within the dynamic chamber was too short to change water vapor. CH_4 pressures of inlet and outlet of the dynamic chamber were corrected using each pressures of water vapor, then the corrected CH_4 difference was used to flux calculation (corrected CH_4 flux, namely $cfCH_4$).

Careful measurements by applying GGA907-0010 provided clear dilution effect for the dynamic chamber, too. $cfCH_4$ sometimes changed to source-CH_4 flux in contrast to sink-CH_4 flux excluding the dilution effect, the correction was additive, thus, the effect was shaded and looked a little when CH_4 flux was higher. However, the correction term, difference between raw CH_4 flux and $cfCH_4$, clearly related to evapo-transpiration rate (sensible heat flux) measured parallel by the dynamic chamber. The linear relationship was exactly the same for different vegetation types on tundra (sphagnum moss, feather moss, heath plant, and almost hallow cavity) by a chamber, and almost the same between the two chambers.

After the manner of WPL-correction for open-path flux measurements, dilution effect for chamber measurements was examined, and the following relationship was defined.

Correction term dCH_4 (g CH_4/s) = -0.00211 lE (W/m^2)

Dilution correction may be carried out by parallel measurement of latent heat flux at vegetation/canopy level. Trace gas flux has been determined by gas-chromatography previously, which could not measure the molar fraction of target gas (dry-air-base), thus, the dilution correction might be applied to most trace-gas flux measured by GC.

PHOTOSYNTHESIS UNDER FOGGY CONDITIONS – A LABORATORY EXPERIMENT

S. C. Chang[1], J. Y. Chiang[1], H. S. Chu[1] and Y. J. Hsia[1]

[1]Department of Natural Resources and Environmental Studies, National Dong Hwa University, Hualien, Taiwan

Plants of cloud forests have fog as one of their determinant physiochemical environment. Under foggy conditions, carbon budget of a cloud forest ecosystem might be affected mainly through the reduction of photosynthesis, which results either from the reduction of incident solar radiation or from the impedance of gas exchange pathway through the stomata by the fog water droplets. At our study site, the Chi-LanMountain site, the low net ecosystem exchange (NEE) of the dominant *Chamaecyparisobtusa* var. *formosana* has been related to the low solar radiation caused by the high frequency and long duration time of fog. To what extent the dark reaction of photosynthesis is influenced by fog, was still not clear to us and thus was the main question of this study. We hypothesized that the net carbon assimilation rate (A_n) will be decreased when the leaves of *Chamaecyparisobtusa* var. *formosana* are wetted by fog droplets.

To test the hypothesis, we conducted a laboratory experiment by simulating different foggy conditions in a growth chamber system and compared the A_n of *Chamaecyparisobtusa* var. *formosana* saplings. The tricky point of such experiment was to separate the effects of fog on the light and on the dark reactions of photosynthesis when fog was being applied in the chamber. To exclude the influence of lowered radiation, we first derived the light response curves of the saplings by giving different shading masks to the light source of the chamber system. The linear part of the curve was determined and the highest light intensity of this linear part (L_{max}) was used for the simulation experiment. During the experiment when fog was sprayed into the chamber, the light intensity on top of the sapling (L_{fog}) was recorded and the respective A_n on the light response curve (A_{dry}) was registered, which represented the A_n that affected only by the reduction of light intensity. The measured carbon assimilation rate (A_{fog}), on the contrary, was the rate that further affected by the wetness of the leaves. By calculating and comparing the ratios A_{fog}/A_{dry} among different fog treatments, we could evaluate the wetting effect of fog droplets on photosynthesis. The CO_2 concentrations in the growth chamber were measured using infra-red gas analyzer (LI-COR 840) and recorded by a datalogger (Campbell CR-3000).

To our surprise, the results of the experiment have rejected our hypothesis. With the effect of lower radiation been excluded, the fog treatments on dry canopies have resulted in an increase in A_n. The A_{fog}/A_{dry} of the saplings was 120%, 126%, and 131% for the fog treatment duration of 10, 30, and 60 min, respectively. It seems likely that the fog droplets did not block the stomata, but have stimulated more opening of the gas exchange pathway and thus more CO_2 assimilation could be observed. To know the effect of longer lasted fog on photosynthesis, we conducted another experiment by spraying the leaves thoroughly and measured the photosynthesis rate. The A_{fog}/A_{dry} dropped to 77%, a value indicating that the photosynthesis pathway was not completely blocked. After the measurement, we let the leaves of the plants dry gradually and measured A_{fog}/A_{dry} 10, 30, and 60 min afterwards and the values were 80%, 87%, and 99% respectively. The photosynthesis rates returned to the level of dry canopy within one hour. Our experiment suggested that tree species in cloud forests might have adapted to the foggy environment by developing a water repellant property of leaf surface, such that photosynthesis could persist under reduced irradiance caused by fog. A study of the physical properties of the *Chamaecyparisobtusa* var. *formosana* leaf surface would be necessary to confirm our observation.

A SEMI-PARAMETRIC MULTIVARIATE GAP-FILLING MODEL FOR EDDY COVARIANCE FLUXES: EVERGREEN FOREST LATENT HEAT FLUX IN CENTRAL TAIWAN AS AN EXAMPLE

Yi-Ying Chen[1] and Ming-Hsu Li[1]

[1]*Graduate Institute of Hydrological Science, National Central University, Taiwan*

Quantitative descriptions of latent heat fluxes are very important to study the water and energy exchanges between terrestrial ecosystems and the atmosphere. Eddy covariance approach is suggested as the most reliable technique for measuring surface fluxes over time scales ranging from hours to years. However, unfavorable micrometeorological conditions, instrument failures, and applicable measurement limitations may cause inevitable flux gaps in time series data using this approach. Thus, development and application of suitable gapfilling techniques are crucial to estimate long term fluxes.

A semi-parametric multivariate gapfilling model was developed for eddy covariance measurements to fill latent heat (LE) flux gaps in this study. This approach combines the advantages of a multivariate statistical analysis (principal component analysis, PCA) and nonlinear interpolation techniques (K-nearest-neighbors, KNN or Multiple regressions, MRS). The PCA was first used to resolve the multicollinearity relationships among various environmental variables, such as radiation, soil moisture deficit, leaf area index, wind speed, and etc. Nonlinear interpolation methods then were used to estimate the gap-filled LE flux based on the score of selected principal components.

The developed LE gap-filling model works with a RMSE of 2.4 W m^{-2} (~ 0.09 mm day^{-1}) at the weekly time scale by adding 40% artificial flux gaps into original dataset. Annual sums of evapotranspiration at this study site were estimated at 736 mm (1802.6 MJ) and 728 mm (1784.6 MJ) for year 2008 and 2009, respectively.

Key words: Gap filling model, principal component analysis, K nearest neighbors, multiple regressions.

CARBON SEQUESTRATION IN OIL PALM PLANTATIONS

Khalid Haron

Malaysian Palm Oil Board
6, Persiaran Institusi, Bandar Baru Bangi, 43000, Kajang, Selangor, Malaysia

Malaysia is the world's second largest palm oil producers with estimated area of 4.85 million ha being planted with oil palm in 2010. Biological sequestration of C in oil palm plantations is one of the better options to reduce atmospheric CO_2 due to its steady sequestration over a period of more than 25-year cycle as its covers a large area for plantation crop in Malaysia.

Planting of oil palm has helped to restore the land-use change areas from forest to be close to that of rainforest in serving as C sink. Oil palm can assimilate up to 36.5t dry matter/ha/yr which is higher than of forest at 25.7t/ha/yr. The net assimilate rate for oil palm at 64.5 t CO_2/ha/yr is better than of forest at 42.2 t CO_2/ha/yr. In term of biomass increment, the oil palm accumulates 8.3t biomass per year as compared to the rainforest at 5.8t. On average, the estimated mean of C sequestration of an oil palm stand with 25-year life span is about 2.09 t C or 7.66 t CO_2 /ha/yr. This shows that oil palm plantation is able to function better as than rainforest as a C sequester.

The estimates of mitigation potential of climate change in the agricultural sector indicates that about 90% of the total mitigation arises from sink enhancement of soil C sequestration and about 10% from emission reduction. In oil palm plantation, biosequestration of C has resulted in an increase of soil C stock over each cycle of 25 years. By practicing zero burning during oil palm replanting, about 85 t /ha of above-ground biomass is available plus about 16 t /ha from below-ground root biomass which contribute to an increase of soil C stock. The non-tillage of the soil when palms are replanted further enhances the accumulation of soil C. In addition, the soil C stock in the oil palm plantation increases with time which is attributed to the added biomass, mainly from the pruned fronds biomass which contribute about 14t dry matter/ha/yr, plus the root biomass and it was found to vary over the palm circle, along the avenue and under the frond piles.

The oil palm biomass or waste from palm oil mill such as palm kernel shell and empty fruit bunches has the potential for C storage. The production of biochar from biomass is one of the means that can sequester carbon for long term for climate change mitigation. Biochar application to soil is a soft geo-engineering approach to sequester carbon while concurrently improving soils. Expanding carbon sinks by enhancing soil carbon in agriculture through biosequestration can be practiced by applying biochar to the soil. Biochar technology captures CO_2 through plant photosynthesis. The captured carbon is then converted into a stable charcoal-like substance called 'biochar', with estimates of characteristic storage time varying from hundreds to thousands to tens of thousands of years to replenish long-term carbon sinks. The International Biochar Initiative estimates that biochar production has the potential to provide 1 Gt carbon per year in climate mitigation by 2040 or 3.67 Gt CO_2 per year, using only waste biomass.
It is concluded that oil palm is a good sequester of C which can help to mitigate global warming and climate change

IMPACT OF CLIMATE CHANGE ON CANOPY CO_2 AND H_2O EXCHANGE OF A TROPICAL RAINFOREST IN PENINSULAR MALAYSIA, PASOH

Yoshiko Kosugi[1], Satoru Takanashi[2], Makoto Tani[1], Shinjiro Ohkubo[3], Naoko Matsuo[4], Masayuki Itoh[5], Shoji Noguchi[6], Abdul Rahim Nik[7]

[1] Graduate School of Agriculture, Kyoto University, Kyoto, Japan
[2] Forestry, Forest Products Research Institute, Tsukuba, Japan
[3] National Agrcultural Research Center for Hokkaido Region, Sapporo, Japan
[4] Faculty of Bioresources, Mie University, Tsu, Mie, Japan
[5] Center for Ecological Research, Kyoto University, Shiga, Japan
[6] Tohoku Research Center, Forestry, Forest Products Research Institute, Morioka, Japan
[7] Ministry of Natural Resources and Environment, Putrajaya, Malaysia

Evaluating the impact of climate change on canopy CO_2 and H_2O exchange of tropical rainforests, and identifying the factors controlling these exchanges at different timescales are of primary importance to understanding the role of gas exchange in the global climate. To clarify the impact of the environmental factors and their future changes on gas exchange processes of tropical forests, we should first evaluate the actual range of their fluctuations as influenced by inter-annual climate variability. Long-term heat, H_2O, and CO_2 flux monitoring based on eddy covariance measurements allows the evaluation of inter-annual range of fluctuation in gas exchange, as well as a detailed analysis of the factors controlling gas exchanges. We investigated inter-annual variation of canopy CO_2 exchange (NEE) and evapotranspiration during a 7-year period over a lowland Dipterocarp forest in Pasoh, Peninsular Malaysia, using the eddy covariance method.

At the study site, annual rainfall fluctuated between 1,451 and 2,235 mm during the 7-year period. Despite of inter-annual variation in rainfall, annual evapotranspiration was stable (1,287 ± 52 mm), except for a slight decrease in at the driest year (2009). Evapotranspiration was roughly related to the amount of available energy, but regulated by stomatal closure to prevent excessive water loss at high vapour pressure deficit. Even during dry periods, no significant decrease in evapotranspiration occurred, as water was supplied from soil layers deeper than 0.5 m. Ecosystem respiration (RE) increased with soil water content. Daytime NEE was also stable during the 7 years despite climate variability. Afternoon inhibition of canopy photosynthesis was seen every month. Daytime NEE did not become more negative with increasing solar radiation, or with increasing soil water content. During dry periods, gross primary production (GPP) and thus canopy gross photosynthesis decreased slightly, coupling with decreased daytime RE. Our results strongly suggest values of GPP and RE of approximately 3,000–3,400 g C m^{-2} $year^{-1}$, and NEE of 0 ± 200 gC m^{-2} $year^{-1}$, with no clear dependence on annual solar radiation or air temperature, and some dependence on rainfall pattern and soil water content.

In this forest, variability in rainfall pattern resulted in seasonal and inter-annual variability in micrometeorology; evapotranspiration, photosynthesis, and ecosystem respiration responded to these changes, and compensated for each other and/or other components of micrometeorology, resulting in rather stable annual evapotranspiration and NEE, even during a considerably dry year associated with an ENSO event. Neither net nor gross canopy CO_2 uptake showed dependence on radiation. However canopy gross photosynthesis and ecosystem respiration showed dependence on soil water content. These results strongly suggest that the reduction in radiation caused by factors such as haze events does not cause a significant change in canopy CO_2 exchange. A decrease in rainfall and soil drought would however cause a decrease in both GPP and RE, resulting in no significant change in NEE, or shift in the direction of CO_2 uptake. We also detected a stomatal regulation of evapotranspiration at high vapour pressure deficit to mitigate excessive evapotranspiration under conditions of high energy, regardless of soil water content. Our results for 2009, an ENSO year, suggest that if more severely dry and hot years occur, the decline in evapotranspiration and GPP caused by the stomatal closure under conditions of higher vapour pressure deficit would increase significantly, to cause the break down of the ‘homeostasis’.

THE CARBON BALANCE OF A TROPICAL RUBBER PLANTATION

Zheng-Hong Tan[1,2], Yi-Ping Zhang[1,2], Qing-Hai Song[1,2], Li-Qing Sha[1], Xiao-Bao Deng[1], Jian-Wei Tang[1], Yun Deng[1], Wen-Jun Zhou[1,2], Hua-Zheng Lu[1], Gui-Rui Yu[3], Xiao-Min Sun[3], Hong-Lin He[3], Wen Su[3], Xiao-Li Ren[3], Naishen Liang[4], Lian-Yan Yang[1,2] and Liang Song[1]

[1]*Key Lab of Tropical Forest Ecology, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun 666303, China*
[2]*Global Change Ecology Group, Key Lab of Tropical Forest Ecology, Chinese Academy of Sciences, Kunming 650223, China*
[3]*Institute of Geographic Sciences and Natural Recourses Research, Chinese Academy of Sciences, Beijing 100101, China*
[4]*Global Carbon cycle Research Section, Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba 305-8506, Japan*
[5]*Graduate University of Chinese Academy of Sciences, Beijing 100094, China*

Regrowth of tropical secondary forest and plantations cannot offset carbon release caused by tropical deforestation and subsequently lead net carbon losses in tropical land. Nevertheless, large uncertainties existed in this estimation. We use an innovated biometric method to estimate net dry matter production and net ecosystem production in a rubber forest which is the most widely spread plantations in tropical Southeast Asia. The biometric-based results were set as a background value and used to track a best data procedure for eddy flux in the studied ecosystem. Ecosystem was a moderate carbon sink (NEP= 287 gC m^{-2} yr^{-1}) according to biometric estimate during the investigate interval. The eddy covariance based annual sum carbon budget is largely dependent on data processing: a large carbon sink (NEE= -904 gC m^{-2} yr^{-1}) after Reichstein u* filtering and gapfilling versus slight net carbon source (NEE=4 gC m^{-2} yr^{-1}) processed by ChinaFLUX procedure. Nighttime ecosystem carbon flux does increasing linearly at low level and saturate at high level of u* as previous assumptions. Nevertheless, it is not the same case for annual sum of NEE estimated from limited available dataset. As micrometeorological theory was most reliable under neutral conditions, we pick the neutral condition dataset out and filled the non-neutral condition data with neutral condition based environmental response equations and obtain a neutral condition based NEE of -267 gC m^{-2} yr^{-1} which is the most close value to biometric estimates. Thus, we would like to recommend the neutral condition method could be used in tropical forest eddy flux data processing. This study did not support that plantation as large carbon sinks. A carbon balance pattern was also established for convenient of further studies.

Key words: carbon sink, eddy flux, biometric method, neutral condition, u* filtering

RUBBER PLANTATION ACT AS WATER PUMPS IN TROPICAL CHINA

Yi-Ping Zhang[1], Zheng-Hong Tan[1], Qing-Hai Song[1], Wen-Jun Zhou[1], Fu Gao[1], Wen-Jie Liu[2], Yun Deng[2], Xiao-Bao Deng[2], Jian-Wei Tang[2] and Lian-Yan Yang[1]

[1]*Global Change Group, Key Lab of TropicalForest Ecology, Chinese Academy of Sciences,Kunming, China*

[2]*Xishuangbanna TropicalBotanical Garden, Chinese Academy of Sciences, Menglun, China*

Whether rubber plantation plays as water pumps in tropical Southeast Asia is under active debate. Fifteen years (1994-2008) paired catchment water observation data and one year paired eddy covariance water flux data in primary tropical rain forest and tropical rubber plantation was provided to clarify how rubber plantation affects local water resources of Xishuangbanna, China. Both catchment water observations and direct eddy covariance estimates indicates that more water was evapotranspirated from rubber plantation (1137 mm based on catchment water balance, 1125 mm based on eddy covariance) than rain forest (969 mm based on catchment water balance, 927 mm based on eddy covariance). Water stored during rainy season is not sufficient for evapotranspiration and lead to zero flow during dry spell in rubber plantation. This directly related to local water resources shortage. This study support that rubber plantations act as water pumps as argued by local people. Here, only the water cycle issue was concerned for large-scale planting rubber tree. Other important environment problems, such as biodiversity loss, carbon release and soil erosion, should be well demonstrated in the following studies.

Key words: rain forest, rubber plantation, water resource, evapotranspiration, catchment, eddy covariance

THE RELATIONSHIP OF VEGETATION DISTRIBUTION AND CARBON STORAGE IN SUBTROPICAL BROAD-LEAVES PLANTATION IN SOUTHERN TAIWAN

Jui-Chu Yu[1], Yen-Jen Lai[1], Ya-Nan Wang[1,2], Ming- Jer Tsai[1,2], and Po-Neng Chiang[1]

[1]The Experimental Forest, NationalTaiwanUniversity, 55750, Nantou, Taiwan
[2]School of Forestry Resources Conservation, NationalTaiwanUniversity,10617, Taipei, Taiwan

FAO reported that the world's total net loss of forest area was 7.3 million hectares per year in the period 2000-2005.Afforestationand reforestationto enhancesequestration ofatmospheric CO_2 is one possible method to mitigation of climate warming. Carbon (C) pools in terrestrial ecosystems are increasing attention because of their potential sequester C capacity. Little was known that sequester C capacity of broadleaves plantation in subtropical area. Therefore, the objective of this study is to clarify the relationship of vegetation distribution and carbon storage in subtropical broad-leaves plantation in southern Taiwan.

The Pingdong long-term ecosystem research site (PD, 22°31', 120°36'E) incluing CO_2 flux tower was also established in 2008 by the ExperimentalForest, NationalTaiwanUniversity (EXFO, NTU), Taiwan. This evergreen broadleaved forest of subtropical and tropical site is located in southern Taiwan at an altitude of 60 ma.s.l. The research site was sugarcane farm before 2002. The sugarcane was removed and fourteen broadleaved species were planted in 2002-2005. The soil belongs to Entisol with over 60% of sandstone. The soil pH is 5.5 with low base cations because of high sand percentage. Mean annual temperature is 25.1 ℃, varied from mean maximum of 28.4 ℃ in July to mean minimum of 20.1 ℃ in January. Mean annual precipitation is 2022 mm. The precipitation is divided two patterns: dry season (October to April) and wet season (May to September). The topography of PD site is relative homogeneous, with an average slope of above 5 °.

Sixteen plots were set on CO_2 flux tower footprint, four subplots were set according FIA plot design. The forest biomass (i.e. tree height, DBH) understory biomass, litter, and soil C were measured and analyzed at February 2011.

The average total C pool of this research site was 27.30 Mg Cha^{-1}, varied from 14.11 to 41.50 Mg C ha^{-1}. The results revealed that the largest C pool was contributed by live tree, average was 21.59 Mg C ha^{-1}, however, wildly ranged from 59.4 % to 87.1 %. The differences of distribution of live tree C pool among 16 plots were affected by growth characteristic of tree species. The C pool contributed from understory, litter, and soil ranged from 0.16% to 10.5%, 0% to 13.04, and 7.75% to 30.13%, respectively. The relationship of C pool of live tree and understory showed significantly negative correlation ($p=0.06$). Soil C content of 0-10 cm was higher than that of 10-30cm, showed that C content was decreasing with depth increased. Soil bulk density was significantly negative related to soil carbon and nitrogen content ($p<0.005$). The domain C pool was contributed by live tree, however, soil C pool size would play the importance of dynamics of decaying litter and tree debris, which influences distribution of carbon pool in subtropical broad-leaves plantation.

THE RELATIONSHIP OF SOIL RESPIRATION VARIATION AND CARBON STORAGE IN SUBTROPICAL BROAD-LEAVES PLANTATION IN SOUTHERN TAIWAN

Jui-Chu Yu[1], Yen-Jen Lai[1], Chih-Yuan Hong[1], Ya-Nan Wang[1,2], Ming- Jer Tsai[1,2], and Po-Neng Chiang[1]

[1]The Experimental Forest, National Taiwan University, 55750, Nantou, Taiwan
[2]School of Forestry Resources Conservation, NationalTaiwanUniversity,10617, Taipei, Taiwan

Greenhouse gases (GHG) concentration increasing is currently one of the most issues in the world. Reducing GHG is one of the prior objectives through reducing GHG emission, energy develop, and GHG fixation. Forests are the greatest source of net primary production in the terrestrial ecosystem. To evaluate efficiency of carbon sink of forest ecosystem would help us to understand forest contribution in the carbon cycling. The eddy covariance method is a well known technique for quantifying carbon flux in the forest ecosystem. However, soil respiration contributed part of carbon budget in the progressing of forest carbon balance. Little was known that soil respiration variation of broadleaves plantation especially in subtropical area. Therefore, the objective of this study is to clarify the relationship of soil respirationvariation and carbon storage in subtropical broad-leaves plantation in southern Taiwan.

The Pingdong long-term ecosystem research site (PD, 22°31', 120°36'E) incluing CO_2 flux tower was also established in 2008 by the ExperimentalForest, NationalTaiwanUniversity (EXFO, NTU), Taiwan. This evergreen broadleaved forest of subtropical and tropical site is located in southern Taiwan at an altitude of 60 ma.s.l. The research site was sugarcane farm before 2002. The sugarcane was removed and fourteen broadleaved species were planted in 2002-2005. The soil belongs to Entisol with over 60% of sandstone. The soil pH is 5.5 with low base cations because of high sand percentage. Mean annual temperature is 25.1 ℃, varied from mean maximum of 28.4 ℃ in July to mean minimum of 20.1 ℃ in January. Mean annual precipitation is 2022 mm. The precipitation is divided two patterns: dry season (October to April) and wet season (May to September). The topography of PD site is relative homogeneous, with an average slope of above 5 °.

Sixteen plots were set on CO_2 flux tower footprint, four subplots were set according FIA plot design. The forest biomass (i.e. tree height, DBH) understory biomass, litter, and soil C were measured and analyzed at February 2011. Soil respiration, water content, and soil temperature (5cm) were measured using Li-8100 equipped survey chamber from January 2011 to June 2011 in 48 subplots. Long term soil respiration system set nearby flux tower was also measured via autochamber.

The average total C pool of this research site was 27.30 Mg Cha^{-1}, varied from 14.11 to 41.50 Mg C ha^{-1}. The average soil respiration rate was 0.12 μmol $m^{-2}s^{-1}$ in this six month, varied from 0.13 to 0.48 μmol $m^{-2}s^{-1}$. It suggested that low soil carbon content (1.64% in 0-10 cm and 1.29% in 10-30cm) resulted in low soil respiration rate. The trend of soil respiration rate was increased with January to June. The soil respiration rate showed significantly correlation with soil temperature ($p=0.012$) using survey chamber method. However, soil water content did not have good correlation with soil respiration rate. The tree age of broadleaves plantation is about 7 years. The canopy closure is low, therefore, soil water content is affected by other environment factors such as wind, sunlight, etc. The data of soil temperature measured by Li-8100 was significantly correlated with soil temperature of flux tower observation ($r^2=0.90$, $p<0.001$). The average of long term soil respiration rate was 0.38μmol $m^{-2}s^{-1}$, varied from 0 to 0.74 μmol $m^{-2}s^{-1}$. The long term data of soil respiration rate also showed significantly correlation with soil temperature ($p<0.001$). On the other hand, soil water content also showed significantly correlation with soil respiration rate ($p<0.001$). Therefore, the data of long term soil water content and respiration rate seem could fill up the gap of survey chamber method.

EFFECTS OF TREE SPECIES ON SOIL MICROBIAL BIOMASS AND SOIL RESPIRATION IN A SUBTROPICAL PLANTATION OF EAST TAIWAN

Chiao-Ping Wang[1], Shih-Chieh Chang[2], Chin-Tzer Duh[1] and Kuo-Chuan Lin[1],

[1]Division of Silviculture, Taiwan Forest Research Institute,Taipei, Taiwan
[2]Institute of Natural Resources, National Dong Hwa University, Hualien, Taiwan

Significant advances have been made in understanding forest carbon cycling and the importance of soil respiration, which correlatessignificantly with soil temperature and moisture and positively with litterfall amounts and NPP at the global scale. However, there is still a large uncertainty about the variability of carbon fluxes at local scales. As forest type and tree species may affect soil respiration by influencing soil microclimate and structure, the quantity and the quality of belowground carbon supply, the soil microbial biomass and activity (heterotrophic respiration), and the overall root respiration (autotrophic respiration), we measured soil respiration rate, litterfall amount, and environmental factors including soil temperature, soil water content, soil C and N content, and soil microbial biomass of 6 kind of subtropical tree plantations (3 plots for each species) to determine how soil respiration is affected by the dominant tree species. According to the canopy density and leaf fall patterns, the plantations were classified into the following groups: 1. sparse canopy and deciduous (*Zelkovaserrata*and *Koelreuteriaformosana*), 2. medium closure (*Liquidambar formosana* and *Fraxinusformosana*), and 3. closed canopy (*Micheliacompressa*and*Elaeocarpusdecipiens*). The study site was established on a well drained sandy loam (TypicDystrudepts) in east Taiwan. Soil respiration was measured monthly from March 2010 to Feb. 2011 using static alkali method while soil microbial biomass C and N was seasonally determined using the chloroform fumigation extraction method. Canopy closure clearly reduced the seasonal variation of soil temperature. Soil respiration exhibited pronounced seasonal variations that well correlated to the temperature while there was no relationship between soil respiration rate and soil water content in our study site. Annual soil respiration rate positively correlated with the litterfall amounts and canopy density. As the litter removal treatment shows no significant effect on soil respiration rates, it indicates that litter layers in this subtropical early stage forest plantation seem to play a less important role on soil respiration than those in the temperate forests. The microbial biomass C and N concentrations of this subtropical plantation are lower than those of temperate forests and similar to the tropical forests. The seasonal change of microbial biomass C and N was significant in both of the sparse canopy and deciduous forests as well as in the *Liquidambar formosana* and *Elaeocarpusdecipiens* forests. Microbial C/N ratios varied significantly in the medium to closed canopy forests except *Fraxinusformosana*. No relationship was found between microbial biomass and soil respiration. Our results suggest the need for further study on the contribution of root respiration to total soil respiration in developing subtropical forest plantations.

GREAT CARBON SINK IN AN ALPINE *KOBRESIA* WETLAND IN THE HINTERLAND ON THE TIBETAN PLATEAU

Peili Shi [1], Yongtao He[1], Xianzhou Zhang[1], Mingyuan Du[2] and Shenyu Cheng [3]

[1] Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, ChineseAcademy of Sciences, Beijing, PR China
[2] National Institute for Agro-Environmental Sciences, Tsukuba, Japan
[3] Faculty Zhejiang Industry University, Quzhou, Zhejiang Province, China

Alpine wetland meadows of *Kobresialittledalei* are widely dispread in the riverside of valleys in the hinterland of Tibetan Plateau. Wetlands could function as carbon sink due to high productivity and lower decomposition. However, little is known about whether the alpine *Kobresia* wetland is carbon sink or source. The aim is to analyze the dynamics, annual net ecosystem CO_2 exchange (NEE) and compare it with carbon budget through biometric method. The NEE of alpine *Kobresialittledalei* wetland was measured by eddy covariance in Damxung flux site, Tibetthrough 2009 to 2010. Net primary production (NPP) and soil carbon effluxes including CO_2 and CH_4 were measured by using closed chamber and chromatography in the two whole years. The wetland ecosystem functions as great carbon sink in the growing season through July to September, with maximum carbon gain of 1.92 mg $CO_2.m^{-2}s^{-1}$in mid August. In total the average annual NEE was 224.81g.C.m^{-2}.The NPP of wetland community was 585.3g.m^{-2}, and the annual CO_2 and CH_4 emission were374.2 g$CO_2.m^{-2}$ and 596.8 mg$CH_4.m^{-2}$ respectively calculating through their regression with temperature. As per the average ratio of similar ecosystems in the plateau, the carbon budget calculating from NPP minus heterotrophic respiration and CH_4 efflux is 221.2 g C.m^{-2}, quite matching carbon flux measurement. These results indicated that the alpine *Kobresia* wetland meadow was a great carbon sink duet to high productivity and small carbon emission. Preservation of alpine *Kobresia* wetland has great carbon sequestration potential in contrast to other ecological engineering in the hinterland of Tibetan Plateau.

Key words: Alpine *Kobresia* wetland meadow, net ecosystem CO_2 exchange, carbon emission, eddy covariance, biometric method, Tibetan Plateau

CO2 FLUX OBSERVATION OF WETLAND IN THE CENTRAL PART OF THE TIBETAN PLATEAU

Mingyuan Du[1], Yongtao He[2], Xianzhou Zhang[2], Seiichiro Yonemura[1], Yingnian Li[3], Fawei Zhang[3], and Liang Zhao[3]

[1]National Institute for Agro-Environmental Sciences, Tsukuba, Japan
[2] Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China
[3] Northwest Institute of Plateau Biology, Chinese Academy of Sciences, Xining, China

The Tibetan Plateau, the highestplateau in the world (average4000m a.s.l.), has a totalwetland area of 50,000km^2. These alpinewetlands contain a large amount of soil organic carbon,which is estimated to compose about 0.2% of the globalpool of soil carbon (Wang et al., 2002). Therefore, it is very important to know the carbon balance in the wetland ecosystems now and how it will be in the future? We have started CO2 flux observation by the eddy covariance method in a wetland at Damxung (30 °28'N, 91 °04'E, 4280m a.s.l.) in the central part of the Tibetan Plateau since May, 2009. In this report we give a comparison between our observation result in 2010 and the observation result (Zhang et al., 2008) in 2005 at Haibei (37 °37'N, 101 °19'E, 3250m a.s.l.) in the northeast part of the Tibetan Plateau.

As shown in table 1, although the altitude of Damxung is about 1000m higher than Haibei, climate condition at Damxung was better (higher air temperature and almost the same precipitation for growing season). Therefore, the vegetation growth was better there (higher biomass and larger leaf area index). Our CO2 flux observation result in 2010 showed that this well grown vegetation was accompanied by a large CO2 absorption in growing season (May to September) than that at Haibei in northeast part of the Tibetan Plateau in 2005. Therefore, this wetland ecosystem was a carbon sink around 150gC/m^2 instead of the carbon source at Haibei in the northeast part of the Tibetan Plateau as shown in Zhang, et al. (2008).

However, there was about 225gC/m^2 of pasture harvest at DamXung wetland in 2010. There was still a carbon source at this wetland considering this harvesting. Human activities including grazing and pasture harvesting play very important rule on the carbon balance at the wetland ecosystem on the Tibetan Plateau and long-term monitoring of the CO2 flux is extremely important to know the change of the large carbonpool and to have a suggestion for scientifically management of the wetland ecosystemson the Tibetan Plateau.

Table 1 Conparison of CO2 flux and other elements between Damxung and Haibei

Stations (observation year)	Description (dominant vagatations and grizing etc.)	Air temperature (℃)		Precipitation (mm)		Maximum biomass above grand (gC/m^2)	Maximum LEA	NEE (gC/m^2)		
		Annual mean	July	May - Sep.	Annual			growing season (May-Sep.)	non growing season	Annual
Damxung (30 ° 28'N, 91 °04'E, 4280m a.s.l.) (2010)	*Kobresia littledalei, Carex doniana*. Winter grizing and pasture harvest*	2.7	11.5	391	416	625	7.4	-235.8	85.9	-149.9
Haibei (37 ° 37'N, 101 °19'E, 3250m a.s.l.) (2005)	*Carex pamirensis, Kobresia tibetica*. Winter grizing only	-1.1	9.8	475	594	331	3.88	-62.8	149.0	86.2

* Harvest amount was about 225gC/m^2 in 2010.

RANGELANDS CARBON SEQUESTRATION ON TIBET PLATEAU – CHALLENGES AND OPPORTUNITIES

Xin-Quan Zhao[1], Liang Zhao[1], Shi-Xiao Xu[1], Hua-Kun Zhou[1], Cai-Yun Luo[1] and Shi-Ping Wang[1]

[1]Northwest Plateau Institute of Biology, The Chinese Academy of Sciences, Xining, Qinghai, 810001, P. R. China.

Rangelands of the Tibetan plateau, although sparsely populated and contributing little to China's overall economy, play an important environmental role throughout Asia. They contain high biodiversity and soil carbon values and can also potentially provide China with a source of cultural and geographic variety in the future.On Tibetan plateau, over grazing of cause the rangelands degradation since the population increasing and livestock too. For the grassland ecosystem services, the capacity of CO_2 captured was singnifically deceased after rangeland degradation. For the 10 years monitoring, overgrazing linding grassland degradation could change alpine meadow from a carbon sink to soruese. Regenerate degraded rangeland could increase the ecosystem carbon accumulation by different treatments which depend on the degree of rangeland degradation. Integrating livestock and crop production couple system was introduce to Tibetan plateau base on the project "green for grain" which means shifting from the traditional systems focused exclusively on livestock or crop to a new approach which sustainably combines both, within the comprehensive framework of the approach and core principles. CO_2 emissions in livestock systems can be reduced through improve nutrients balance from summer and winter. The amount of methane and CO_2 produced per unit of animal product can be reduced by feeding better quality diets to sheep and yaks. This increased efficiency could be achieved through improved land-use management with practices such as improved fodder technologies (development of fodder banks, improved pasture species, and others) and supplementation with crop by-products. These practices, which are cost effective and available in eastern part of plateau, can increase efficiency milk and meat production, and, together with reductions in the number of animals, help mitigate CO_2 emissions from ruminant systems and decrease grazing pressures of nature pasture. In the region, many low-producing animals could be replaced with fewer but better-fed animals, thus reducing total CO_2 emissions while maintaining or increasing the supply of livestock products.

MEASUREMENTS OF CARBON DIOXIDE FLUXES AND ENERGY BALANCE OVER A SUBURBAN ECOSYSTEM IN A TROPICAL CITY

Matthias Roth[1] and Christer Jansson[2]

[1]National University of Singapore, Department of Geography, Singapore
[2]Swedish Meteorological and Hydrological Institute, Norrköping, Sweden

Vertical turbulent flux densities of carbon dioxide, the turbulent fluxes of the energy balance and all components of the radiation flux were measure between March 2006 – March 2008 above a residential neighborhood in Singapore, located about 100 km north of the equator. Standard eddy covariance instrumentation was mounted at the top of a pneumatic mast at 20.7 m above ground level or about 2.5 times the height of the 2-3 story high buildings characteristic of the measurement site. Turbulent source areas representing the range of atmospheric stability encountered during the study period show little directional variability and demonstrate that signals measured at the top of the tower usually originated from areas covered by homogeneous suburban land-use (generally within 500 m of the tower for unstable and near-neutral conditions). In total 11 month of data were analyzed divided into monsoon seasons to examine possible influence of the different wind regimes on the fluxes.

This presentation will focus on the diurnal and seasonal variability of the carbon dioxide fluxes and energy balance components. Special emphasis will be on the role of the vegetation in mitigating urban ecosystem carbon dioxide emissions. The present carbon dioxide results will be compared to other (sub)urban flux measurements which are becoming increasingly available and are collected in the Urban Flux Network database (http://www.geog.ubc.ca/urbanflux/).

EVAPOTRANSPIRATION AND CLIMATIC SUITABILITY OF RICE PLANTING REGION IN CHINA

JuqiDuan[1, 2] and Guangsheng Zhou [1, 3]

[1] Chinese Academy of Meteorological sciences, Beijing, China
[2]School of Atmospheric Physics, NanjingUniversity of Information Science and Technology, Nanjing, China
[3] State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing, China

At present, one of unresolved critical issues relating to climate change is whether evapotranspiration (ET) is increasing or decreasing with global warming. There has been great interest, therefore, in studying ET in a variety of ecosystems to better understand the nature of the controlling interactions and the links between ET and ecosystem adaptability. In order to discover the effects of evapotranspiration and other interactive controls on rice (including single and double rice) planting region in China, evapotranspiration and its relationship with the potential distribution of rice planting region in China would be studied in this paper.

In terms of potential climate factors affecting rice distribution selected from the related literatures based on regional and annual scales, single and double rice geographic information from national agrometeorological observation stations of China Meteorological Administration (CMA), together with maximum entropy model (MaxEnt) and spatial analyst function of ArcGIS software, major climate factors affecting potential distribution of single and double rice plant region in China would be clarified, and relationship between potential distribution of single and double rice planting region and climate would be developed.The results show that annual precipitation (P), moisture index (MI) and days of not less than 18 ℃ stably (N_{18}) are dominant climate factors affecting potential distribution of single rice planting region in China, contributing 94.6% of all potential climate factors. The dominant climate factors affecting potential distribution of double rice planting region in China include annual precipitation (P), mean temperature of the warmest month (T_W) and days of not less than 18 ℃ stably (N_{18}), which contributing 99.1% of all the potential climate factors. Potential distribution of single and double rice planting region in China is simulated well in terms of MaxEnt and the selected dominant climate factors as well as the geographic information of single and double rice. Furthermore, the climatic suitability divisions of single and double rice planting region in China are given based on its appearance frequency. The climate characteristics of single and double rice planting region in each climatic suitability region are analyzed, respectively. It also indicated that effects of evapotranspiration are different due to different rice types and different planting region, and usually they are obvious stronger on single rice than on double rice. The results not only could provide scientific basis for optimizing rice allocation of production and modifying cropping pattern, but also could improve water use efficiency.

Key words: single rice; double rice; evapotranspiration; potential distribution; climatic suitability; dominant climate factors; maximum entropy model

FLUXNET – A UNIQUE OPPORTUNITY TO INTEGRATE DATA, KNOWLEDGE AND PEOPLE

Dario Papale

DIBAF – University of Tuscia, via C. de Lellis, 01100 Viterbo, Italy

The FLUXNET network is providing direct measurements on the 'breathing of the terrestrial biosphere'. The CO_2, water and energy exchange between the terrestrial biosphere and the atmosphere measured at the eddy covariance sites is giving us insights on how ecosystem metabolism to climatic perturbations and disturbances across a spectrum of time scales and different ecosystem and climate regimes. FLUXNET data are critical for validating and improving the next generation of mechanistic models, that are being used to compute coupled climate-ecosystem interactions and biogeochemical cycling of carbon and water.

The current FLUXNET database (www.fluxdata.org) assembles data from more than 250 sites, encompassing all major biomes of the world and being processed in a standardized way. This unique dataset provides copious amounts of information about the fluxes characteristics and their responses to climate and disturbances. The methods available to estimate from Net Ecosystem Production (NEP) the two main components Gross Primary Production (GPP) and Total Ecosystem Respiration (TER) give possibilities to analyze the relations between these three quantities and their link to climate variables like temperature and precipitation and to disturbances, while the water fluxes permit to look at the water/carbon cycles interactions. At the same time the long time-series available for many sites (up to 14 years) offer the opportunity to analyze the interannual variability of fluxes and the effect of extreme climate conditions.

The importance of these measurements in a long term perspective is also confirmed by the recent development of the Integrated Carbon Observation System infrastructure (ICOS) in Europe and similar networks in US (NEON).

In this talk ICOS will be presented together with the FLUXNET future plans, including new development in uncertainty estimation and data processing techniques, highlighting how these measurements can be used to estimate carbon and water fluxes are regional, continental and global scale and in others synthesis studies to better understand the ecosystem-climate relations.

NETWORKING FLUX RESEARCHES TO ASSESS THE CARBON BALANCE OF TROPICAL PEATLAND ECOSYSTEMS IN SE ASIA

Takashi Hirano

Hokkaido University, Sapporo, Japan

Tropical peatlands are widely distributed over 4.4 $\times 10^5$ km^2 and store soil carbon up to 88.6 Pg, which accounts for 15-19% of global peat carbon (Page *et al*., 2011). The huge carbon pool is presently disturbed on a large scale by land development and management, and consequently has become vulnerable. Peat degradation occurs most rapidly and massively in Indonesia, where 2.07 $\times 10^5$ km^2 of peatlands exist, because of fires, drainage and deforestation of swamp forest. Peat burning releases carbon dioxide (CO_2) intensively but occasionally, whereas drainage would increase CO_2 emission steadily through the acceleration of aerobic peat decomposition. Therefore, tropical peatlands has the potential to switch to a large carbon source. However, the ecosystem-scale carbon exchange between tropical peatlands and the atmosphere is unknown.

To assess the carbon balance of tropical peatland ecosystems and the effects of disturbances on the carbon balance, we started eddy CO_2 flux monitoring in three peatland ecosystems with different disturbance levels in Central Kalimantan, Indonesia. We are going to make a network of eddy flux sites in tropical peatlands, including Malaysian sites, for a large-scale assessment.

LESSONS LEARNED FROM CARBOEASTASIA: BACK TO BASICS

Joon Kim[1] and CarboEastAsia Contributors

[1]Complex Systems Science Lab., Department of Landscape Architecture and Rural Systems Engineering, SeoulNationalUniversity, Seoul, 151-921, Korea

The major objectives of CarboEastAsia are to (1) identify the mechanisms that drive carbon cycling; (2) quantify carbon sink/source distribution, dynamics and uncertainty; (3) establish standardized datasets for synthesis, assessment and prediction; (4) understand how ecosystems respond and adapt to disturbances; (5) develop carbon cycle models suitable for East Asia; (6) evaluate the influence of land use and climate changes; and finally (7) provide scientific insight for the role of East Asian ecosystems in global carbon balance and their management toward sustainability.

As the result of our four years' collaborations so far, CarboEastAsia has established a standardized dataset from 35 tower sites (mostly in forest and agricultural ecosystems) in China, Japan and Korea. From this database, key mechanisms driving carbon cycles have been identified, but there seems to be no surprising finding despite the predominant influence of the Asian summer monsoon, for example. The seasonal and inter-annual variations of carbon sink/source strength are relatively large and closely coupled with changes in hydrological cycle. However, these phenomena have been poorly reproduced by most of the carbon cycle models and satellite-based remote sensing algorithms. Furthermore, the uncertainty associated with measurement and modeling is yet to be quantified. The terrestrial carbon sinks in East Asia are speculated to decline if natural and human disturbances exceed the resilience of the ecosystems in this region.

Observational evidence suggests that complexity and heterogeneity in terrestrial ecosystems in East Asia play an important role in the non-trivial emergent and self-organizing interactions with their environment, which may facilitate to build resilience for adaptation to changes and disturbances. Yet, the principles that characterize the role of variability and the consequent adaptation of ecosystems in such interactions remain elusive. Rapidly increasing human disturbances in East Asia necessitates the understanding of the complex social-ecological systems in a novel framework. As a first step toward bridging ecosystem science with services and stewardship, the science and research underlying the complex social-ecological systems should focus not only on the concepts of energy, force, and matter, but also on those of feedbacks, information, communication, and purpose. Resilience-based system approach suggests that complex systems evolve through active adaptive cycles to cope with change. Ecohydrologic and biogeochemical processes associated with carbon and water cycles can be viewed as a network of processes of a wide range of scales involving various feedback loops. Finding such networks of feedback loops for key ecosystems in monsoon Asiais urgently needed. Along with these additional efforts, however, it is probably more important to get back to basics - "asking the right questions." Perhaps, a physicist Erwin Schrödinger's (i.e., *What is life?*) or a biologist John Sulston's (i.e., *How do we ensure humanity survives and flourishes?*) would be an exciting starting point to find ways to breakthroughs.

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SPATIAL AND TEMPORAL PATTERNS OF THE CARBON BUDGET IN ASIA AND THE UNCERTAINTY CAUSED BY DIFFERENT GAP-FILLING PROCEDURES

Saigusa N.,[1] S.-G. Li,[2] H. Kwon,[3] K. Takagi,[4] J. Hong,[5] R. Ide,[1] M. Kang,[3] Z. Leiming,[2] M. Ueyama,[6] J. Asanuma,[7] S.-J. Han,[8] T. Hirano,[9] R. Hirata,[9] Y.-N. Li,[2] T. Maeda,[10] A. Miyata,[11] Y. Mizoguchi,[12] S. Murayama,[8] Y. Nakai,[13] T. Ohta,[14] T.M. Saitoh,[15] H.-M. Wang,[2] G.-R. Yu,[2] Y.-P. Zhang,[2] and F.-H. Zhao[2]

[1]National Institute for Environmental Studies, Tsukuba, Japan
[2] Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing, China
[3] Seoul National University, Seoul, Korea
[4]HokkaidoUniversity, Toikanbetsu, Japan
[5]National Institute for Mathematical Sciences, Daejeon, Korea
[6] Osaka Prefecture University, Sakai, Japan
[7] University of Tsukuba, Tsukuba, Japan
[8]Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, China
[9]HokkaidoUniversity, Sapporo, Japan
[10]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan
[11]National Institute for Agro-Environmental Sciences, Tsukuba, Japan
[12] Forestry and Forest Products Research Institute, Sapporo, Japan
[13]Forestry and Forest Products Research Institute, Tsukuba, Japan
[14]NagoyaUniversity, Nagoya, Japan
[15]GifuUniversity, Gifu, Japan

The net ecosystem CO_2 exchange (NEE) was estimated at 21 forests, 3 grasslands, and 3 croplands in Asia based on the eddy covariance measurements as a part of international joint program called as 'CarboEastAsia'. The program was conducted by three member networks of China, Japan, and Korea (ChinaFLUX, JapanFlux, and KoFlux), aiming at quantifying, synthesizing, and understanding of carbon fluxes and storages in Asia.

At the beginning of the program, an inter-comparison was conducted for the values of NEE, gross primary production (GPP) and terrestrial ecosystem respiration (RE) estimated by three different computational procedures adopted by ChinaFLUX, JapanFlux, and KoFlux in order to test the range of uncertainty caused by different methods of quality-control and gap-filling. The overall comparison indicated a good agreement among the three procedures for estimating half-hourly NEE during active growing seasons, while different quality-control with regard to unrealistic downward CO_2 flux in mid-winter sometimes caused detectable bias in NEE. The influence of using different flux-partitioning methods was also tested for quantifying GPP and RE. High variability was found in the values of RE particularly in high temperature seasons, suggesting that further studies were critically necessary to establish better criteria for improving flux partitioning algorithms.

Based on the quality-controlled and gap-filled datasets, comparisons of magnitude and seasonality of carbon budget components were made among different biome types, phenology, and stress conditions. The results suggested that the annual values of GPP estimated in the 21 forest sites were almost proportional to the annual air temperature over wide latitudinal ranges from Siberia to tropics, except for a few sub-tropical and warm temperate forests where serious drought stress reduced carbon uptake in mid-summer. The effects of artificial and natural disturbances, such as forest managements (tree age), severe drought stress, and defoliation caused by strong winds were significant factors that influenced the CarboEastAsia forest sites. The different timing and length of the growing period due to different agricultural managements resulted in notable seasonal patterns of NEE in crop sites. In the cool-temperate and alpine grasslands, the temperature and water conditions mainly regulated the annual production. The CarboEastAsia dataset, obtained from a wide variety of ecosystems in Asia would be a unique and essential source of knowledge as well as a validation dataset for developing advanced techniques in modeling and remote sensing to update the terrestrial carbon budget estimations in Asia.

ENVIRONMENTAL CONTROLS OF THE VARIABILITY OF RADIATION USE EFFICIENCY ACROSS DIFFERENT FOREST ECOSYSTEMS IN EAST ASIA

Leiming Zhang[1], Shenggong Li[1] and Guirui Yu[1]

[1]Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, ChineseAcademy of Sciences

The evaluation of terrestrial carbon uptake in Asia has received more and more attention. Carbon uptake by terrestrial ecosystem at different spatial and temporal scales is often estimated with the radiation use efficiency (RUE) model. Mostly, the maximum or potential RUE is set as a constant within each vegetation type, which assumed the vegetation type alone is the main control of RUE. The actual RUE is estimated by downregulated the potential RUE with temperature, water stress in models to estimate GPP.

Under the influence of East Asian monsoon, East Asia is a unique region due to continuous forest biome distribution along the temperature and precipitation transect, which includes boreal forest, temperate deciduous forest, temperate mixed forest, warm temperate forest, subtropical evergreen forest, and tropical rain forest. The spatial and temporal variations of radiation use efficiency across different forest ecosystems along such transect are not yet fully understood.

Based on the long term flux data from ChinaFLUX, KoFlux and JapanFlux, which supported by the Carboeastasia (A3 project), the objectives of this study are to 1) analyze the spatial pattern of potential radiation use efficiency (RUE) across different forest ecosystems in East Asia; 2) elucidate the biological and environmental controls on RUE both within and among forest types across the forest transect.

EFFECTS OF BIOTIC OR ABIOTIC FACTORS ON THE SPATIAL PATTERN OF WUE AMONG ECOSYSTEMS IN CHINA

Xianjin Zhu[1] and Guirui Yu[1]

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

Water use efficiency (WUE) is important for quantifying the efficiency of water resources. It is also an index presenting the coupling between carbon and water cycles. Carbon and water exchanging between ecosystem and atmosphere mostly achieves through stomata, and stomata would stay in the optimal status by self-adjusting, thus WUE has some conservative characteristics.While in most cases, WUE shows robust variability, including diurnal, seasonal, annual variations as inferred in many published papers. Therefore WUE is an index containing two 'conflicting' properties: conservative and variability. Understanding the spatial characteristic and patterns of WUE would provide convincing information to help decide how to manage regional resource of carbon and water more efficiency, it would also laya foundation to researches on carbon and water cycles- the core of climate change and ecology management.

The aims are to find the spatial pattern of WUE through ecosystems distributed in different part ofChina, and to dig out factors which affect the variability of WUE. We also want to investigate the underlying mechanisms of the spatial pattern of WUE.

Based on data from multi-year observations of ChinaFLUX, we have the ratio of the annual accumulated GPP and ET as WUE. As a result, the mean WUE in Chinawas 1.83 gC $kg^{-1}H_2O$, which was lower than that in European and was similar with that in America. Forests had higher WUE than grasslands. In spatial, WUE increased linearly with the increase of longitude, while no significant relationship was found between WUE and latitude. Furthermore, WUE was significantly affected by air temperature and leaf area index (LAI), their relationship exhibited asa convex parabolic curve (Figure 1). WUE can be separated into two parts: GPP/T and T/ET. The variability of WUE were mainly controlled by GPP/T, and GPP/T also showed a convex parabolic trend when the air temperature and LAI increased, thus WUE varied with the change of air temperature and LAI. And the mechanism- why GPP/T varied with different abiotic and biotic factors- would be discussed later.

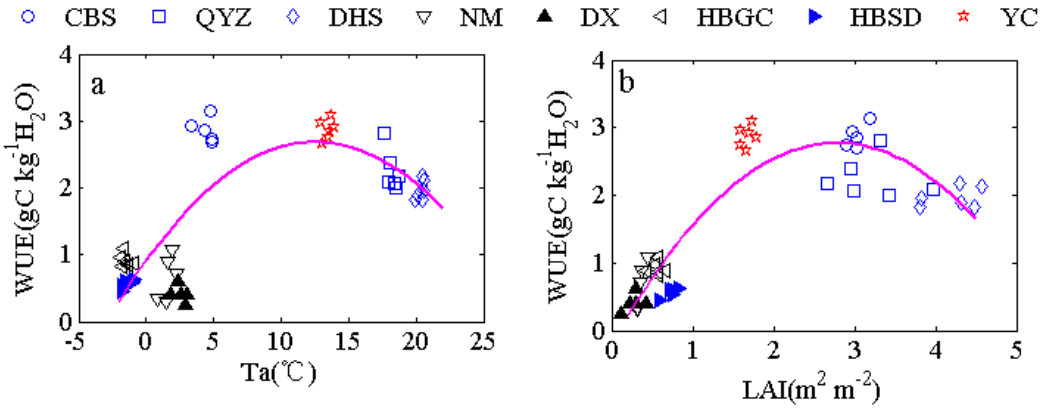

Figure 1 Water use efficiency (WUE) varied with annual mean air temperature (Ta, a) and leaf area index (LAI, b) in spatial

Note: Letters in the legend were abbreviations of ecosystems in ChinaFLUX.

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CHARACTERIZING THE SPRING RECOVERY RATE OF CANOPY PHOTOSYNTHESIS IN TEMPERATE FOREST AND GRASSLAND ECOSYSTEMS USING FLUX DATA

Yuling Fu [1], Guirui Yu [1], Lianhong Gu[2], Jie Zhuang[3], Randy Gentry[3], Paul Hanson[2] , Mi Zhang[1]

[1]Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, 11ADatun Road, Anwai, Beijing 100101, China
[2] Environmental Sciences Division, Oak Ridge National Laboratory, Knoxville, USA
[3]Institute for A Secure and Sustainable Environment, The University of Tennessee, Knoxville, USA

The carbon balance of terrestrial ecosystems is particularly sensitive to climatic changes in spring and autumn (Goulden et al., 1998, Piao et al., 2008), with spring and autumn temperatures over northern latitudes having risen by about 1.1 ^{o}C and 0.8 ^{o}C, respectively, over the past two decades (Mitchell and Jones, 2005). Warmer air temperatures are hypothesized to cause an earlier onset of photosynthetic activity in northern hemisphere ecosystems in spring (Menzel and Fabian, 1999; Cayan et al., 2001). Nevertheless, the underlying physiological mechanism and associated triggers determining the timing and recovery rate of spring plant photosynthesis innorthern ecosystems are not well understood (Tanja et al., 2003; Ensminger*et al*., 2004; Slot *et al*., 2005; Ensminger*et al*., 2008).

In our study, we evaluated the spring recovery process of plant community photosynthesis at canopy level across different ecosystems and biomes with eddy covariance flux data. This study is based on a global collection of eddy covariance CO_2 flux observations—the FLUXNET LaThuile Database. We analyzed the eddy-covariance-based GPP data measured over deciduous broadleaf forest, evergreen needleleaf forest and grasslands in temperate zone of Northern Hemisphere. The recovery day and recovery rate of GPP in early spring was characterized by using a phonological model of canopy photosynthetic capacity (CPC) developed by Gu et al (2003, 2009). Then we analyzed the relationship between the recovery rate of GPP and the variation of environmental factors and compared the difference among different ecosystem types. The hypothesis is that deciduous broadleaf forests and grasslands are more sensitive to temperature change in spring than evergreen needle leaf forests, probably due to the differences in the life history strategy between deciduous and evergreen leaves.

UNDERESTIMATED EFFECTS OF LOW TEMPERATURE DURING EARLY GROWINGSEASON ON CARBON SEQUESTRATION OF A SUBTROPICAL CONIFEROUSPLANTATION

Huimin Wang[1], Wenjiang Zhang[1,2], Fengting Yang[1], Xuefa Wen[1], Xiaomin Sun[1], Guirui Yu[1]

[1]Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences andNatural Resources Research, ChineseAcademy of Sciences, Beijing, China
[2]State Key Laboratory of Hydraulics and MountainRiver Engineering, SichuanUniversity, Chengdu, China

The impact of air temperature in early growingseason on the carbon sequestration of a subtropical coniferous plantation was discussed through analyzing the eddy fluxobservations at Qianyanzhou (QYZ) site in southern Chinafrom 2003 to 2008. This site experienced two cold earlygrowing seasons (with temperature anomalies of 2–5 ◦C) in2005 and 2008, and a severe summer drought in 2003.Results indicated that the low air temperature from January to March was the major factor controlling the inter-annual variations in net carbon uptake at this site, ratherthan the previously thought summer drought. The accumulative air temperature from January to February showedhigh correlation (R^2 =0.970, p <0.001) with the annual netecosystem production (NEP). This was due to the controlsof early-month temperature on the plant phenology developing and the growing season length at this subtropical site.The cold spring greatly shortened the growing season lengthand therefore reduced the carbon uptake period. The eddyflux observations showed a carbon loss of 4.04 g Cm^{-2} pergrowing-season day at this coniferous forest site. On theother hand, the summer drought also reduced the net carbonuptake strength because the photosynthesis was more sensitive to water deficit stress than the ecosystem respiration.However, the impact of summer drought occurred within arelatively shorter period and the carbon sequestration wentback to the normal level once the drought was relieved.

UNCERTAINTY IN EDDY COVARIANCE MEASUREMENTS OF CARBON FLUX AT DECIDUOUS AND CONIFEROUS FORESTS IN COMPLEX TERRAIN, KOREA

Hyojung Kwon[1], Jin-Chun Woo[2], Chun Jung Hwa[3] and Joon Kim[4]

[1]National Center for Agro Meteorology, Seoul National University, Seoul 151-921, Korea
[2] Division of Metrology for Quality of Life, Korea Research Institute of Standards and Sciences, Daejeon, Korea
[3]Division of Forest Ecology, Korea Forest Research Institute, Seoul 130-712, Korea
[4] Complex Systems Science Lab, Department of Rural System Engineering, Seoul National University, Seoul 151-921, Korea

Eddy covariance measurement can be subject to uncertainty due to sampling error, calibration error, instrument limitation, and measurement conditions, which are in conflict with the underlying assumption. Therefore, quantifying the magnitude of uncertainty can be essential for data analysis and interpretation. Uncertainty in eddy covariance measurements was assessed for carbon flux using half-hourly data obtainedfrom the two major KoFlux sites (i.e., deciduous forest site, GDK and coniferous forest site, GCK) from 2008 to 2010. Uncertainty over the half-hourly data was aggregated to estimate annual uncertainty, and then it was compared to annual carbon flux. In our analysis, we only considered five components of uncertainty such as one point sampling, calibration, WPL correction, frequency response correction, and gap-filling application, which were dominant sources of uncertainty in the measurements. When estimated using the data collected from favorable measurement conditions (e.g., enhanced turbulent mixing during daytimes), the average absolute uncertainty varied from 0.47 to 0.55mg CO_2 m^{-2} $s^{-1}$for GDK site and 0.63 to 0.69mg CO_2 m^{-2} s^{-1} for GCK site. The corresponding relative uncertainty ranged from 64 to 74% for GDK site and 87 to 104% for GCK site. Uncertainty of one-point sampling contributed on average more than 83% to the total uncertainty for both sites. Annual carbon budget varied from-43 to -125 g C m^{-2} for GDK site and -114 to 346 g C m^{-2} for GCK site. The annual absolute and relative uncertainties were 24-48 g C m^{-2} and 19-111% for GDK site and 32-41 g C m^{-2} and 9-36% for GCK site, respectively. Despite the similar magnitudes of the annual absolute uncertainty for both sites, the lower estimation of the relative uncertainty at GCK site was due to a higher annual carbon budget at GCK site compared to that at GDK site. In the presentation, more results will be reported.

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LESSONS LEARNED FROM CARBOEASTASIA MIP: CURRENT STATUS OF TERRESTRIAL CARBON CYCLE MODELING IN ASIA

Ichii K[1], Y.-H. Lee[2],W. Ju[3],S. Wang[4],M. Kondo[1],A. Ito[5],T. Sasai[6],T. Suzuki[1],M. Ueyama[7], J. Kim[8], J. Asanuma[9], S.-J. Han[10], T. Hirano[11], R. Hirata[11], H. Kwon[8], Y.-N. Li[12], T. Maeda[13], A. Miyata[14], Y. Mizoguchi[15], Y. Matsuura[16], S. Murayama[13],Y. Nakai[16], T. Ohta[6], T.M. Saitoh[17],N. Saigusa[5],K. Takagi[18], T. Tang[5], H.-M. Wang[4], Y.-P. Zhang[4] and F.-H. Zhao[4]

[1]*Fukushima University, Fukushima, Japan*
[2]*Kyungpook NationalUniversity, Daegu, Korea*
[3]*NanjingUniversity, Nanjing, China*
[4] *Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing, China*
[5]*National Institute for Environmental Studies, Tsukuba, Japan*
[6]*NagoyaUniversity, Nagoya, Japan*
[7]*OsakaPrefectureUniversity, Nagoya, Japan*
[8]*Seoul National University, Seoul, Korea*
[9]*University of Tsukuba, Tsukuba, Japan*
[10]*Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, China*
[11]*HokkaidoUniversity, Sapporo, Japan*
[12]Northwest Institute of Plateau Biology, CAS, Xining, Qinghai, China
[13]*National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan*
[14]*National Institute for Agro-Environmental Sciences, Tsukuba, Japan*
[15]*Forestry and Forest Products Research Institute, Sapporo, Japan*
[16]*Forestry and Forest Products Research Institute, Tsukuba, Japan*
[17]*GifuUniversity, Gifu, Japan*
[18]*HokkaidoUniversity, Toikanbetsu, Japan*

Within CarboEastAsia framework, we, CarboEastAsia Model Intercomparison Project members, are conducting multi model and data comparison and synthesis aiming at (1) identify the mechanisms that drive carbon cycle, (2) quantify carbon sink/source distribution, (3) develop terrestrial carbon cycle models suitable for Asia, (4) evaluate the influence of land use and climate changes, and (5) provide scientific insight for the role of East Asian ecosystems in global context. At more than 25 sites in monsoon Asia, we conducted the terrestrial carbon cycle model simulations using about 10 models (e.g. BEAMS, BEPS, Biome-BGC, CASA, CLM-DGVM, LPJ, TRIFFID, VISIT) from 1901 to 2010, and the model outputs are evaluated with CarboEastAsia observation dataset. Through the model evaluation with site observation, several common limitations in the model at the site scale are found. For example, the model overall underestimate the seasonal magnitude of terrestrial carbon cycles (e.g. gross primary productivity and net ecosystem exchanges) at most sites. The abnormal seasonality in NEE (carbon releases in rainy season in some sites) due to the unique monsoon climate in Asia is not captured by many models. Overall, carbon cycle seasonality in tropical forests are not represented well by most models. We will report current status of existing terrestrial ecosystem models at CarboEastAsia sites, and discussthe issues and ways for further improvements toward our aims mentioned above.

Acknowledgement.
We thank ChinaFLUX for providing flux and meteorological data. The JapanFlux data sets were produced by the support from A3 Foresight Program of JSPS. The KoFlux data were produced by the support from A3 Foresight Program of National Research Foundation and a grant (Code: 1-8-3) from SustainableWaterResourceResearchCenter of 21st Century Frontier Research Program of Korea. The study is also supported by the Environment Research and Technology Development Fund (RF-1007) of the Ministry of the Environment of Japan.

AN EVALUATION OF COMMUNITY LAND MODEL (CLM) 3.5-CN AT GRASSLAND

Y. H. Lee[1], H. J. Lim[1], K. Ichii[2], J. Asanuma[3], and Y. Guirui[4]

[1]Kyunpook NationalUniversity, Daegu, Korea
[2]FukushimaUniversity, Fukushima, Japan
[3]University of Tsukuba, Tsukuba, Japan
[4]Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing, China

This study was performed as part of model inter-comparison study in East Asia and here we focused on the performance of CLM3.5-CN at grassland site in East Asia. The model includes both carbon and nitrogen cycle. The model requires meteorological driver, nitrogen deposition input, and initial carbon pool. For nitrogen deposition, we adopted the value of 0.20 g m^{-2} yr^{-1} and 0.25 g m^{-2} yr^{-1} for KBU and HBG sites, respectively from global nitrogen deposition dataset by Dentener (2006). To get an equilibrium carbon and nitrogen pools, we performed spin-up run for 910 years using climate data for the period from 1901 to 2010 repeatedly. Climate driver was made based on NCEP reanalysis data, CRU data and GISS radiation data and adjusted to fit the site observation. For 800 years, model was run with fixed CO_2 concentration in 1901 and for remaining 110 years, varying CO_2 concentration for 110 years were used. The time variation of nitrogen deposition was not considered in this simulation. Two grass sites in East Asia were examined. Both sites are characterized by low annual precipitation amount and low temperature during the winter due to high latitude or high altitude. Observed NEE data at these sites show significant carbon uptake during growing season. Simulated NEE show much less carbon uptake during growing season than observations and simulated maximum LAI was about 0.5. Model phenology simulates later start and later end of growing season than observations. For KBU site, used precipitation amount in climate driver was higher than observed one. Therefore, both soil moisture and latent heat flux were significantly overestimated. To examine performance of carbon exchange simulation of model in water stressed condition, we performed several simulations for the year of 2006 at KBU site. The study year was selected because observed input meteorological data and fluxes have little gap in the year. Observed precipitation amount was examined with observed soil moisture data for consistency check. With observed precipitation and low initial soil moisture, the model captured seasonal variation of both latent and sensible heat fluxes. But model did not simulate carbon uptake and LAI during growing season with default parameter setting. Other deficiencies of CLM-CN also have been discussed.

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AN EVALUATION OF COMMUNITY LAND MODEL (CLM) 3.5-CN OVER TEMPERATE DECIDUOUS FOREST

H. J. Lim[1], Y. H. Lee[1], K. Ichii[2], J. Kim[3], H. Kwon[3], and H. Kondo[4]

[1]Kyunpook National University, Daegu, Korea
[2]Fukushima University, Fukushima, Japan
[3]Seoul National University, Seoul, Korea
[4]National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan

This study was performed as part of model inter-comparison study in East Asia and here we focused on the performance of Community Land Model version 3.5 with coupled Carbon and Nitrogen cycles (CLM-CN) over temperate deciduous forest.Observed flux data at Gwangneung(GDK) in Korea and Takayama(TKY) in Japan were compared with model simulations. Model run was done in three steps, To get the equilibrium carbon pools, the model was integrated for 800 years using climatological driver data from 1901 to 2010 and fixed atmospheric CO_2 concentration in 1901, repeatedly. To consider the increase of carbon dioxide during 110 years, we run the model with increasing atmospheric CO_2 concentration and climatological data with equilibrium carbon pool during the period from 1901 to 2005. For comparison with observations, model was run for study years with the observed atmospheric input data at each site and equilibrium carbon pools obtained from spin-up process. For nitrogen deposition input, we used values from global nitrogen deposition dataset. At both sites, the simulated annual NEEs show weak carbon source which is not consistent with observations. At GDK site, model captures seasonal variation of NEE, but, overestimates significantly the magnitude of RE and GPP in late summer. At TKY site, model poorly simulated the annual cycle and magnitude of NEE due to significantly underestimation of GPP during growing season. Although two sites are located in similar latitude and have similar maximum LAI, observations show that GPP in summer is higher at TKY site than in GDK site. It seems that due to lower temperature and higher humidity, forest at TKY site rarely experience high vapour pressure deficit whereas forest at GDK site can experience temporary water stress in late afternoon in clear day due to higher temperature in summer. Possible reason for underestimation of NEE at TKY site is relatively low nitrogen deposition (0.8 g m^{-2} yr^{-1}) at TKY site compared to the value (1.5 g m^{-2} yr^{-1}) at GDK site. The used global nitrogen deposition data with low resolution may under-represent the nitrogen deposition value at this site. Simulated maximum LAIs (about 4.5 m^2 m^{-2} at both sites) were comparable to the reported values at both sites, and timing of leaf out and leaf fall was well simulated at both sites. Several sensitivity tests were performed in related to LAI seasonality and nitrogen deposition rate. Other deficiencies of CLM-CN also have been discussed.

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SIMULATING THE EFFECTS OF PLANTATION ON CARBON ASSIMILATION AND EVAPOTRANSPIRATION IN A SUBTROPICAL CATCHMENT UTILIZING A HYDRO-ECOLOGICAL MODEL

Shi Hao[a, b], Wang Shaoqiang[a, *], Zhou Lei [a, b], Yang Fengting[a], Wang Jingyuan[a], Wang Huimin[a]

[a]Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, 11A, Datun Road, Anwai, Beijing 100101, PR China

[b]Graduate School of Chinese Academy of Sciences, Beijing 100049, PR China

Plantation in southern China has been playing a main role in sequestering carbon from atmosphere since the 1980s. To investigate the implication of plantation on ecosystem carbon assimilation and evapotranspiration (ET), we executed a simulation from 1985 to 2007 in a small subtropical catchment using Regional Hydro-Ecologic Simulation system (RHESSys) model for counting up the effects of complex terrain on carbon and water cycles. The model was calibrated against the observed gross primary productivity (GPP) in 2004 and then validated by GPP data during 2005-2007. The annual GPP, ecosystem respiration (RE), net ecosystem productivity (NEP) and ET were examined by measured eddy covariance flux data from 2003 to 2007. Our results indicated that, during 1985-2007, annual GPP, RE, ET and LAI increased from 994.2 to 1955.5 $gCm^{-2}y^{-1}$, from 610.5 to 1585.1 $gCm^{-2}y^{-1}$, from 794.2 to 1165.2 mm, and from 1.72 to 4.07 m^2m^{-2}, respectively, while NEP increased firstly and then decreased to a steady state at about 360.4 $gCm^{-2}y^{-1}$. Further analysis suggested that after plantation matured in 1999, annual GPP was influenced by both mean annual temperature (MAT) and annual precipitation but the effect of precipitation was larger; annual RE had a significant exponential relation with MAT and NEP was mainly influenced by precipitation; during 1985-2007, annual ET increased as LAI varied without obvious MAT or precipitation effects. In the end, we evaluated the model behavior and discussed its applicability in subtropical region within complex terrain.

A MULTI-SITE SIMULATION OF DIFFERENT FOREST ECOSYSTEMS IN EAST ASIA BASED ON PNET-CN MODEL

Hao Shi[1], Shaoqiang Wang, Lei Zhou

[1]*Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing, China*

Climate change, atmosphere [CO2] increase and disturbances (e.g., drought, flood, fire and insect) have made great impact on carbon cycle of different forest ecosystems in East Asia. Ecosystem modeling is a powerful tool to diagnose or predict the responses of components of forest ecosystems including vegetation and soil carbon pools and carbon, nitrogen and water fluxes. It's very important to understand the model behavior in kinds of ecosystems and further improve the model accuracy. In this study, we applied the PnET-CN model, based on foliar nitrogen concentration, to some flux sites with different plant function types and compared their simulation effects for finding out the deficit of which part of the model lead to the discrepancy between observed and simulated data. Meanwhile, we discussed the temperature dependence of ecosystem respiration (RE) in different temporal scales and its spatial pattern. Our results suggested that minimum temperature (T_{min}) correlates better than maximum temperature (T_{max}) with RE and the underestimation of RE by average temperature (T_{ave}) gets less as temporal scale increases. We also argued that maybe T_{min} is a better indicator or at least a potential substitute of T_{ave} in quantifying RE, especially in understanding the temperature implication on ecosystems.

MODEL BASED ESTIMATE OF GLOBAL CARBON BUDGET WITH OPTIMIZATION: TOWARD APPLICATION OF GOSAT PRODUCTS

Masayuki Kondo[1] and Kazuhito Ichii

[1]Fukushima University, Fukushima, Japan

Estimation of carbon exchange in terrestrial ecosystem associates with difficulties due to complex entanglement of physical and biological processes. It is often the case that the net ecosystem productivities (NEP) estimated from simulation often differ by process-based terrestrial ecosystem models. In addition to the complexity of the system, validation can only be conducted in a point scale because reliable observations are only available from ground observations. With a lack of spatial measurements, extension of model simulation to a global scale would result in significant uncertainty in the future carbon balance and climate change.

Greenhouse gases Observing SATellite (GOSAT), launched by the Japanese space agency (JAXA) in January, 2009, is the 1st operational satellite promised to deliver the net land-atmosphere carbon budget to the terrestrial biosphere research community. It is not only expected to yield the current global carbon budget, but also to be used in refinement of terrestrial ecosystem models and inversion-based estimation of global map of terrestrial biosphere properties including biomass, vegetation types, and other associated vegetation properties. Using that information the model reproducibility of carbon budget is expected to improve: hence, gives a better estimation of the future climate change.

This initial analysis was conducted to seek and evaluate the potential applications of GOSAT observation toward the sophistication of terrestrial ecosystem model. To achieve the objective, a prototype of an optimization wrapper tool which is applicable to most of existing ecosystem models by design was developed. Using this tool, first, we conducted site-based analysis using eddy covariance observation data to assess the potential for use of terrestrial carbon flux (GPP, RE, and NEP) to refine the model. Second, using CarbonTracker product as a prototype of GOSAT product, we extended the point scale analysis into spatial one. Finally, it would be discuss the potentials use of GOSAT data to invert terrestrial vegetation parameters.

MAPPING 500 M NET PRIMARY PRODUCTIVITY AND WATER USE EFFICIENCY IN CHINA USING MULTI-ANGLE REMOTE SENSING DATA

Ju Weimin[1], Liu Yi Bo, Zhou Yanlian, and Zhu Gaolong

[1]*International institute for earth system science, Nanjing University, Nanjing 210093, China*

Net primary productivity (NPP) acts as an important component of terrestrial carbon cycle and affected by various factors, including climate, CO_2 concentration, atmospheric nitrogen deposition and human activities. The combination of remote sensing and process-based ecological models is an effective way to estimate regional/global of NPP. In this study, 500 m 8-day composite reflectance and BRDF products of MODIS were used to generate the leaf area index and clumping index over China during the period from 2001 to 2010 using the algorithms developed from the 4-scale geometric model. The LAI and clumping index were then used in conjunction with meteorological data interpolated from meteorological station records to force the BEPS model to map NPP and water use efficiency (WUE) in China at 500 m resolution.

Validations show that the BEPS model is able to reproduce observed NPP and evapotranspiration at site and regional scales. NPP and WUE exhibit distinguishable spatial patterns in China. Extreme climate abnormality can cause regional NPP to reduce significantly. The temporal trends of NPP and WUE during 2001 and 2010 are spatially heterogeneous.

Key words: Net Primary Productivity, Water Use Efficiency, BEPS model, MODIS

SOIL CARBON EMISSION OF TROPICAL ECOSYSTEMS AND ITS POTENTIAL ROLE IN REDD++ MECHNISM

Naishen Liang[1], M. Takada, T. Okuda[2], E. Philip and Rahim A. Nik

[1]Global Carbon cycle Research Section, Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba 305-8506, Japan
Graduate School of Integrated Arts and Sciences, Human/Environmental/Cultural Sciences, Department of Natural Scineces, Hiroshima University.

The tropical ecosystems have been estimated to be a large carbon source (1.3 Pg C yr^{-1}) due to deforestation and forest degradation, even the global terrestrial carbon sink has been large (1.1 Pg C yr^{-1}) in recent decades. Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, offering incentives for tropical region to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. The ultimate goal of this study is to update REDD mechanism through improved forest management by evaluation of effects of logging and land-use change on soil carbon emission of tropical forests.

This study was conducted in lowland and mountainous tropical forests in Peninsular Malaysia. We partitioned soil CO_2 efflux (R_s) into autotrophic (R_r) and heterotrophic (R_h) respirations from 2004 by using an automated chamber system at a lowland primary forest at Pasoh Forest Reserve (2º58' N, 102º18' E; 75~150m a.s.l.), each with eight chambers (65×50×50 cm; L×W×H). In addition, from August 2010, we measured R_s every two weeks at the primary, logging, secondary forests as well as rubber and oil palm plantations at Pasoh and Temenggor concession area (5º33' N, 101º36' E; 800~900m a.s.l.), by using a portable system that coupled with two automated chambers (32 cm in diameter and 30 cm high) (Fig. 1). R_s at the primary forests (six plots) was averaged to 6.63 (ranging between 4.59 and 8.17) μmol $CO_2 m^{-2} s^{-1}$, with R_h contributed to about 52% (ranging between 37~62%). After five years logging, R_s at the Sustainable Management System (SMS) and low-impact (removed 30% of biomass) logging sites was 6.60±2.36 and 5.58±2.68 μmol $CO_2 m^{-2} s^{-1}$, respectively. However, R_s at a 50-year-old secondary forest was 3.99±1.46 μmol $CO_2 m^{-2} s^{-1}$, suggesting that decomposition of the harvest residue and new inputted course wood debris (CWD) contributed a large part of R_s at the logging sites. Furthermore, R_s at rubber and oil palm plantations was 3.17±0.94 and 4.81±2.57 μmol $CO_2 m^{-2} s^{-1}$, respectively, probably due to biomass decreased about 70~90% as compared to the primary forest.

About 50~65% biomass was harvested and soil temperature increased about 3ºC with SMS, resulting value of the carbon stock lost about 247 US$ ha^{-1}following the first year of logging. On the other hand, under low-impact harvest condition, only about 124 US$ ha^{-1} was lost following the first year of logging. Result suggests that this low-impact harvest system would achieve about 123 US$ ha^{-1} of REDD credit partially contributed from mitigating soil degradation of about 55 US$ ha^{-1}.

Fig. 1. Measuring soil CO_2 efflux by using the automated chamber systems.

APPLYING TUNABLE DIODE LASER SPECTROSCOPY FOR CONTINUOUS MEASUREMENT OF METHANE FLUX AT A FOREST CANOPY WITH A RELAXED EDDY ACCUMULATION METHOD

M. Ueyama[1], Y. Takai[1], K. Hamotani[1], Y. Takahashi[2], K. Takahashi[3], and Y. Kosugi[3]

[1]Osaka Prefecture University, Sakai, Japan
[2] National Institute for Environmental Studies, Tsukuba, Japan
[3]KyotoUniversity, Kyoto, Japan

Methane (CH_4) is a second largest greenhouse gas. Compared with CO_2, our understanding of CH_4 budget, cycle, and its processes is poor. Forest ecosystems are thought to be a second largest CH_4 sink owing to the oxidation under aerobic soils, but it is difficult to quantify the budget due to large heterogeneities. Canopy-scale micrometeorological measurements are promising to measure the fluxes integrating large spatial areas. Previously this method was rarely applied for evaluating CH_4 flux at forest canopies because certain gas analyzer was not available to measure small CH_4 flux at forests. In this study, we introduce a continuous canopy-scale micrometeorological measurement at a larch forest to applying our developed relaxed eddy accumulation (REA) system and a state-of-the-art tunable diode laser spectrometer (TDLS).

The measurement has been conducted at a planted larch forest (35°N26', 138°45'), which locates on the northern foothill of Mt. Fuji, Japan. We started measurements at August 2011 by renewing previous our REA system with a flame ionization detector (FID) (Ueyama et al., *under review*). CH_4, CO_2, and H_2O concentration were measured by a TDLS (GCA-24EP, Los Gatos Research Inc.). The analyzer was automatically calibrated once a day. The installed REA system was similar to our previously validated ones (Ueyama et al., 2009; *J. AgricMeteorol*.), and measured CH_4 and CO_2 fluxes, simultaneously; updraft and downdraft air at 35 m was separately sampled to the reservoirs. In addition to the fluxes, the system simultaneously measured vertical CH_4, CO_2, and H_2O concentration at 35, 27, 18, 5, and 0.3 m above the ground. Dilution effect of H_2O to CH_4 and CO_2 concentration was corrected. The system was verified with simultaneous measurements of CO_2 flux by the eddy covariance method.

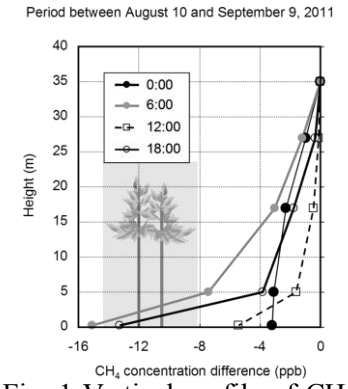


Fig. 1 Vertical profile of CH_4 concentration relative to that measured at 35 m.

According to the vertical concentration profile, the forest soil generally consumed CH_4 during the period between August 10 and September 9, 2011 (Fig. 1). The CH_4 concentration decreased with decreasing height. The vertical concentration difference was large in nighttime compared with in daytime, probably because the atmospheric mixing was restricted in the nighttime. Because high CH_4 concentration near soil was occasionally observed in nighttime (data were not shown), deplete in CH_4 concentration near the soil was not clear at 0:00 for the ensemble mean in Fig. 1.

Measured fluxes showed that the forest acted as a CH_4 sink for the study period for both daytime and nighttime (Fig. 2), which was consistent with the profile measurement. The flux had a clear diurnal variation; uptake in daytime was larger than in nighttime.Measured concentration difference between updraft and downdraft air was on average -0.18 ppb for daytime and -0.09 ppb for nighttime, which were less than the precision of the TDLS examined by a frequency stability analysis, about 0.3 ppb, indicating that further improvements of the TDLS, the REA system, and data processing could be required for evaluating individual half-hourly fluxes.

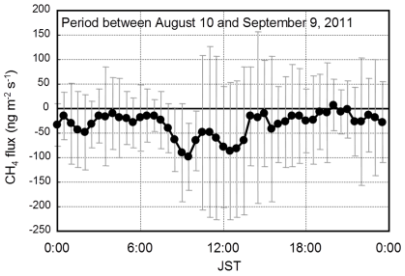


Fig. 2 Mean diurnal variation of CH_4 flux.

BIOGENIC VOLATILE ORGANIC COMPOUNDS FLUXES ABOVE LARCH FOREST MEASURED USING A RELAXES EDDY ACCUMULATION METHOD

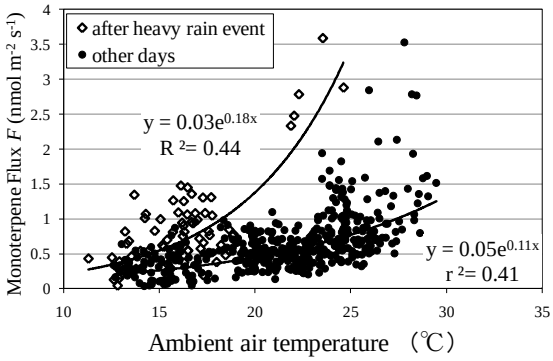
T. Mochizuki[1], M. Ueyama[2], Y. Takahashi[3], N. Saigusa[3], M. Okumura[4], S. Tohno[4] and A. Tani[1]

[1]GraduateSchool of Nutritional and Environmental Sciences, University of Shizuoka, Shizuoka, Japan
[2]School of Life and Environmental Sciences, OsakaPrefectureUniversity, Osaka, Japan
[3]National Institute for Environmental studies, Tsukuba, Japan
[4]GraduateSchool of Energy Science, KyotoUniversity, Kyoto, Japan

Biogenic volatile organic compounds (BVOC) emitted from vegetation can significantly contribute to photochemical reactions. Annual BVOC emissions have been estimated to be 1150 Tg carbon per year, which is higher than the anthropogenic volatile organic compounds (AVOC) emission. Terpenoids, such as isoprene and monopterpenes, are estimated to comprise half of the global BVOC emissions from vegetation. In addition, they include 5 or 10 atoms of carbons in one molecular, and therefore BVOC emissions from forests may significantly affect the forest carbon cycle. In the present study, we measured BVOC emission fluxes above a Japanese larch forest from spring to fall to produce BVOC inventory across Japan.

The study was conducted at the Fuji-Hokuroku site (FHK: 35º 26' N, 138º 45' E, elevation 1050~1150m) near Mt. Fuji, Japan. BVOC fluxes were measured above a Japanese larch (*Larixkaempfen*) plantation (tree ages: 45~50 years, canopy height: 20~25 m) using a meteorological tower built within the site. BVOC fluxes were measured at 30-minute intervals (from 8:00-17:00) from September 2010 to August 2011 except for the defoliation period (from November 2010 to April 2011). We sampled the BVOCs using a portable REA sampling system, and analyzed them with gas chromatography mass spectrometry (GC-MS). The basal emission flux was determined using the G93 algorithm $\{F = F_{30}\exp[\beta(T-30)]\}$, where F_{30} is the basal flux potential (30 ℃), β is the temperature dependence coefficient, and T is the ambient air temperature.

BVOCs identified as compounds emitted from the larch forest included isoprene, α-pinene, sabinene, myrcene, and β-pinene. Major compounds were isoprene and α-pinene. We confirmed that isoprene was emitted from a forest floor plant (*Dryopteriscrassirhizoma*) and all the monoterpenes from the Japanese larch.



To investigate effect of temperature on the monoterpene flux F, we plotted F against ambient air temperature (Fig. 1). F seemed to depend mainly on the temperature, but it tended to be higher after heavy rain event.
F was found to increase exponentially with temperature. G93 algorithm yields F_{30} values of 8.76 (β = 1.13) nmol m^{-2} s^{-1} and 1.33 (β = 0.11) for the days after heavy rain event and remaining days, respectively. F_{30} value for the remaining days was an intermediate range among the reported data for monoterpene emitters. On the other hand, we found that heavy rain resulted in high F_{30} and β.

BIOGENIC VOLATILE ORGANIC COMPOUND STUDY FROM A TEMPERATE FOREST IN CHANGBAI MOUTAIN

Jianhui Bai[1], Wan Xiaowei[1], Alex Guenther[2], Andrew Turnipseed[2], and Tiffany Duhl[2]

[1]Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China, 100029
[2]National Center for Atmospheric Research, Boulder, CO 80307, USA

Biogenic volatile organic compound (BVOC) emissions were measured in a temperate forest, ChangbaiMoutain, China during the growing season in 2010 along with meteorological parameters including global radiation and PAR. BVOC flux measurements were made by relaxed eddy accumulation (REA) on an above canopy flux tower. The monoterpene emission at this site was dominated by α-pinene, terpinolene, o+p-cymene, d-limonen, camphene, myrcene with averaged emission fluxes of 0.068, 0.053, 0.045, 0.037, 0.025, 0.025 mg m^{-2} h^{-1}, respectively during the growing season. The highest emission fluxes of the above monoterpenes were 0.21, 0.32, 0.28, 0.20, 0.36, 0.43 mg m^{-2} h^{-1}, respectively. For the identified 12 monoterpene species, the mean total flux was 0.22 mg m^{-2} h^{-1} and ranged from 0.01 to 1.67 mg m^{-2} h^{-1}.

Measurements were conducted from 6:30 to 18:30 with 3-h interval to investigate the diurnal variations of BVOC. The highest monoterpene emissions occurred in the afternoon with lower emissions in the morning and late evening. In addition, the highest monoterpene emission appeared 3 hours later than that of PAR on most days (Fig.1) and appeared simultaneously with the peak of air temperature on some days (Fig. 2).

An empirical model was developed for calculating monoterpene emission flux based on PAR energy conservation, the calculated flux was in agreement with the observed.

Key words: Biogenic volatile organic compound, monoterpene, relaxed eddy accumulation, Changbai Mountain.

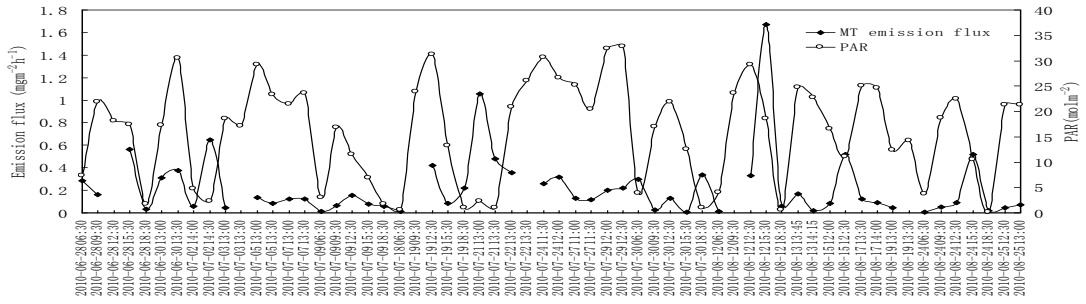


Fig. 1 Monoterpene (MT) emission flux and half hour sum of PAR during the growing season in Changbai Moutain

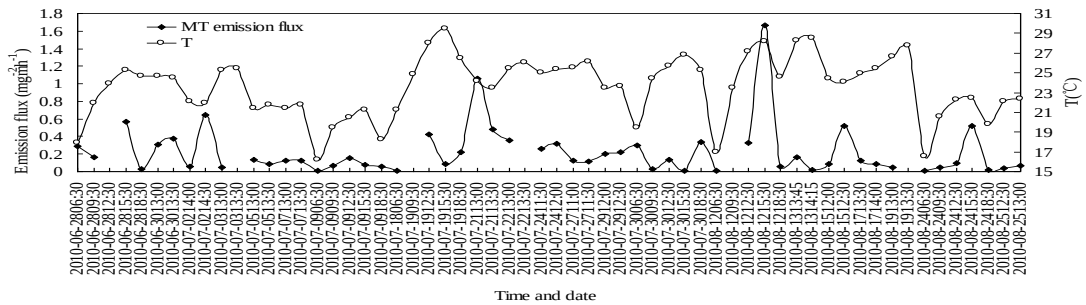


Fig. 2 Monoterpene (MT) emission flux and temperature (T) during the growing season in Changbai Moutain

CARBOHYDRATE STORAGE: WHY DO TREES BOTHER?

P Thaler

Cirad, UMR Eco & sols, Montpellier, 34000, France

Trees store a large part of the assimilated C in parenchyma, mainly in trunks and taproots, and this has huge consequences on the dynamics of C of forest and tree-crops ecosystems. For example, carbohydrates stored in the stems of oil palm trees can represent up to 20 % of vegetative dry matter (Legros et al 2006). Biomass increment is a major component of C balance and it is usually estimated by measurements of new-grown organs. But if a significant part of the growth of organs comes from the remobilization of reserves, the total biomass increment can be largely overestimated. This can result in wrong estimates of NPP and imbalance between flux measurements and biomass measurements. Hence, the study of reserve dynamics on an ecosystem scale is of first importance.

However, recent reviews (Millard et al 2007) concluded, from observations of forest responses to rising atmospheric CO_2 or from dynamics of carbohydrates in trees, that the growth of trees is not C-limited. Actually, the level of C stored in parenchyma seems rather constant, even when tree growth is constrained by temperature (tree-line in mountains, Hoch and Körner 2003). This lack of depletion of stored C leads several authors to the conclusion that the trees do not need this extra C for their growth. So, why do they bother in accumulating it?

From the work of our team on rubber tree and oil palm tree and from literature review, we suggest that one issue is the non-explicit hypothesis that growth is always the priority sink in trees (after reproduction).We demonstrated that artificially increasing the C demand through tapping for latex production leaded to an increase in C storage, at the expense of growth. Hence, the C reserve pool is not only a passive tank, filled when supply exceeds demand, but a sink competing with other sinks and which may be priority to growth. This conclusion is discussed on the basis of the necessity for trees to store large amounts of C for long term survival. New researches on the impact of C allocation within the ecosystem on the total C balance are consequently proposed.

USE OF ECOSYSTEM FLUX DATA AND A SIMULATION MODEL TO EXAMINE SEASONAL DROUGHT EFFECTS ON A SUBTROPICAL CONIFEROUS FOREST

Na Mi[1,2], Guirui Yu[2], Xuefa Wen[2], Xiaomin Sun[2], Shusen Wang[3], Leiming Zhang[2], Xia Song[2]

[1]Institute of Atmospheric Environment, China Meteorological Administration (Shenyang), Shenyang, China
[2]Synthesis Research Center of Chinese Ecosystem Research Network, Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China
[3]Canada Centre for Remote Sensing, Ottawa, Canada

The Qianyanzhou (QYZ) forest site is located in the mid-subtropical region under typical subtropical continental monsoon climate. Despite its plentiful water and heat resources, changes in their seasonal distributions result in frequent occurrences of seasonal drought, influencing both the structure and function of forest ecosystems. In order to examine the effects of drought stress on energy and water fluxes and the related physiological processes, we used tower flux measurements of 2003 and 2004 from the QYZ site and the ecosystem model EALCO (Ecological Assimilation of Land and Climate Observations). The model explained almost 90% of the variance in the daily LE for both years; whereas 71% and 55% of the variance in H for 2003 and 2004, respectively. Simulations suggested that, during the 2003 summer drought, about 80% of water extraction by roots occurred below 0.45 m, and canopy stomatal conductance decreased in response to soil dryness at a threshold θ_r (relative water content) of 0.5 m. The response of canopy stomatal conductance appeared to be linked to the soil water exposed to the majority of the roots, even if substantial water was being extracted from greater depth. The decrease of canopy stomatal conductance made the ratio of transpiration to ET relatively constant along the years with only a small difference. The different extent of the seasonal drought resulted in different water fluxes for the two years with more distinct influence on evaporation than on transpiration.

IMPACTS OF TREE PLANTATIONS ON CARBON, WATER CYCLE AND NUTRIENT CYCLES: THE CASE OF RUBBER PLANTATIONS IN SOUTH EAST ASIA.

Gay, F.

CIRAD, UMR Eco&Sols, Research and Development Building, Kasetsart University, Bangkok, 10900, Thailand.

Tree plantations are agricultural lands planted with woody or non-woody species for the production of agricultural products principally. In some case, they can also provide timber or firewood. Tree plantations, more particularly rubber and oil palm ones, have been in the middle of major land use change issues in SEA for the last decades. SEA countries concentrate about 90% and 70% of the surface area under rubber and oil palm plantations respectively, for a total of more than 18 millions of hectare. Coffee and cocoa plantations represent substantial surface areas as well, with about 3 to 4 millions ha. The expansion of rubber plantations in countries like Thailand, Laos or Vietnam illustrates well the current dynamics of tree plantations in the area. Surprisingly, the information about the carbon, water and nutrient cycles in these major ecosystems in SEA are still poor. This paper proposes a review of the existing knowledge about the impact of tree plantations on carbon, water and nutrient cycles, with a special emphasis on rubber plantations. It also presents some results from flux experiments carried out by our team on this kind of ecosystems in the tropical area.

Poster Session

CO_2 EXCHANGE IN TROPICAL PEATSWAMP FOREST IN SARAWAK, MALAYSIA

Musin K.K.[1], Puking A.[1], Daniel J.[1], Aeries E.B.[1], Sang D.[1], Tang A.[1], Ah-Came J.D.[1], Hirata R.[2] and Melling L.[1]

[1]Tropical Peat Research Laboratory Unit (Chief Minister's Department), Sarawak, Malaysia
[2]Graduate School of Agriculture, Hokkaido University, Japan

Tropical peatswamp forest is both a tropical rainforest and a wetland. It is supposed to be very efficient carbon sequester and storing ecosystems due to its potential for high biomass production and the carbon as tropical peat soil. As compared to temperate peatland forest, there are still very limited studies on tropical peatswamp forest in relation to its CO_2 exchange and meteorological variations. These limited studies had led to a gap of knowledge and understanding on the tropical peatswamp forest ecosystems especially a long term and continuous measurements of CO_2 flux. In January 2011, an ecosystem study via the eddy covariance technique was established at Maludam National Park (01º 27' 14.8'' N 111º 8' 45.3'' E), Sarawak, Malaysia. Canopy height of the National Park is 30 – 35 m. The objective of this study is to correlate the relationship between the CO_2 flux and the environmental parameters. CO_2 flux was measured using an eddy covariance technique with both open and closed path system. The meteorology variables were measured using sonic anemometer-thermometer, net radiometer, quantum sensor, 3-cup anemometer and wind vane, temperature and relative humidity probe, water contain reflectometry and water level logger. Precipitation at 1 m height was measured with tipping-bucket rain gauge. Initial results for seven months from January until July 2011 had shown that the min and max value of CO_2 flux was recorded in Jun 2011 (-129.81 μmol $m^{-2}s^{-1}$) and January 2011 (-90.01 μmol $m^{-2}s^{-1}$) respectively. The mean value for incoming and outgoing long radiation is 2425.53 Wm^{-2} and 459.88 Wm^{-2} respectively while incoming and outgoing short radiation is 206.31 Wm^{-2} and 19.69 Wm^{-2} respectively. The mean value for incoming and outgoing photosynthetic active radiation is 329.34 μmol $m^{-2}s^{-1}$ and 278.34 μmol $m^{-2}s^{-1}$ respectively. Meanwhile the mean value for groundwater level was observed to be at +1.9 cm.

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CARBON BALANCE OF A LOGGED OVER TROPICAL PEATSWAMP FOREST IN SARAWAK, MALAYSIA

Aeries E.B.[1], Sang D.[1], Puking A.[1], Musin K.K.[1], Tang A.[1], Ah-Came J.D.[1], Hirata R.[2], and Melling L.[1]

[1]Tropical Peat Research Laboratory Unit (Chief Minister's Department), Sarawak, Malaysia
[2]Graduate School of Agriculture, Hokkaido University, Japan

Tropical peatswamp forest is important in their role as carbon sinks and stores but there are still limited data availability concerning its carbon balance and their biological controls. This study aims to evaluate the carbon balance of a logged over tropical peatswamp forest by using the eddy covariance technique. The carbon dioxide (CO_2) flux measurements have been conducted in a logged over tropical peatswamp forest in Sarawak, Malaysia (01°24'01.6''N, 111°23'54.0''E). Measurements had started since January 2011. The logged over forest is a Padang Paya Swamp Forest and is almost flat with an elevation of about 8 m above mean sea level. The dominant species for the overstory is *Litsea* spp. with heights up to 25 m. The eddy covariance system consists of an open path infrared CO_2/H_2O gas analyser and a three dimensional sonic anemometer installed at 40 m above ground. CO_2 profile is measured using a closed path system. Supporting meteorological measurements include solar radiation, photosynthetically active radiation (PAR), wind speed and direction, temperature and relative humidity, soil temperature, volumetric water content, rainfall as well as groundwater level monitoring (GL). Initial results from January to July 2011 had shown that, minimum and maximum CO_2 flux is recorded at May (-144.99 μmol $m^{-2}s^{-1}$) and January (-67.38 μmol $m^{-2}s^{-1}$) respectively. The average downward and upward short radiation is 202.04 Wm^{-2} and 19.24 Wm^{-2} respectively. Upward and downward long radiation is observed to be at 404.13 Wm^{-2} and 434.05 Wm^{-2} respectively. Meanwhile, downward and upward PAR is 347.29 Wm^{-2} and 24.42 Wm^{-2} respectively. Average GL was observed to be at -5.3 cm.

METEOROLOGY VARIABLES IN AN OIL PALM PLANTATION ON TROPICAL PEATLAND

Sang D.[1], Tang A.[1], Baran A.E.[1], Musin K.K.[1], Sitam A.[1], Ah-Came J.D.[1], Hirata R.[2], and Melling L.[1]

[1]Tropical Peat Research Laboratory Unit (Chief Minister's Department), Sarawak, Malaysia
[2]Graduate School of Agriculture, Hokkaido University, Japan

Recently, there has been a great concern on the impact of land use change on greenhouse gas emission and its implication and contribution to global warming and climate change. As part of the needs for economic development, eradicating rural poverty and creating job opportunities, there has been an increase in oil palm development on tropical peatland. Tropical peatland is also the last frontier of arable land for large scale plantation. Oil palm is a very important vegetable oil because it is one of the most affordable oil. However, there has been a global concern on the development of tropical peat swamp for oil palm plantations due to deforestation and drainage. Therefore, a study has been embarked to establish the understanding of the relationship of carbon flux and the management of an oil palm plantation on tropical peatland. An eddy covariance technique has been employed to investigate the carbon balance of an oil palm plantation on tropical peatland. It has been established in Sibu, Sarawak, Malaysia (N2°11'12.0" E111°50'31.9"). While trying to determine the carbon balance of the oil palm ecosystems on tropical peatland, ancillary measurement such as solar radiation, photosynthetic active radiation (PAR), soil moisture, soil and air temperature, relative humidity and precipitation were being measured. The objective of this paper is to determine the meteorological variables of an oil palm ecosystem on tropical peatland. The average of short solar radiation for downward and upward was 195.09 Wm^{-2} and 24.71 W m^{-2}, while for long solar radiation was 407.51 W m^{-2}, 438.42 W m^{-2} respectively. The overall mean for downward and upward PAR are 365.31 µmol $m^{-2}s^{-1}$ and 20.93 µmol $m^{-2}s^{-1}$ respectively. The soil moisture at 10 cm and 30 cm depth was 0.50 m^3 m^{-3}. It was closely related with the precipitation. Soil temperature at 5 cm and 10 cm depth had amplitude ranging from 23.5°C to 28.3 °C with mean of 25.5 °C. Meanwhile, the overall mean of air temperature at the site was 26.1°C. The total volume of precipitation for seven months was 1170.9 mm. Therefore, it is important to investigate the meteorological variations as they can be the factors in prompting the CO_2 flux.

SEASONAL CHARACTERS OF CO_2 FLUX ABOVE URBAN GREEN SPACE IN PEARL RIVER DELTA, CHINA

Sun Chun-Jian[1, 2] and Wang Chun-Lin[1]

[1] Climate Center of Guangdong Province, Guangzhou，China
[2] Nanjing University of Information Science and Technology, Nanjing, China

Urban green space plays a significant role in the process of city carbon cycle. Accurate estimation of CO_2 flux above urban green space using long term field-observation provides critical information for climate change reaction as well as regional carbon sequestration evaluation. Continuous eddy-covariance measurements of CO_2 flux was conducted in Dongguan meteorological bureau in 2009 and 2010, with which annual variations of net ecosystem CO_2 exchange (NEE) and its controlling meteorological factors were analyzed. Major results are as follow: (1) Annual total NEE is $-104.2 gC \cdot m^{-2} \cdot a^{-1}$, indicating that urban green space is a carbon sink. (2) NEE varies seasonally with environmental factors such as light and temperature. Urban green space acts as a carbon source from December to March (next year), and a carbon sink from April to Nov. in a year. (3) Using daytime NEE and photosynthetic active radiation (PAR), formulated by Michaelis-Menten model, the annual average apparent light use efficiency (α) was 0.00134 ± 0.00035 $mgCO_2 \cdot \mu mol^{-1}$ Photons and the maximum photosynthetic productivity (P_{max}) was 1.006 ± 0.283 $mgCO_2 \cdot m^{-2} \cdot s^{-1}$. (4) Calculated by exponential equation between night respiration (R_{eco}) and soil temperature at 5cm depth (T_s), annual R_{eco} was 1378.1 $gC \cdot m^{-2} \cdot a^{-1}$. (5) Correlation analysis between NEE with PAR, air temperature (T_a), and saturation vapor pressure differential (VPD), indicates that partial correlation coefficient of PAR is bigger than others, means that PAR is the most important controlling factor of NEE.

CHARACTERISTICS OF TEMPORAL VARIATIONS IN ECOSYSTEM CO_2 EXCHANGE IN A TEMPERATE DECIDUOUS NEEDLE-LEAF FOREST IN FOOTHILL OF HIGH MOUNTAIN

Y. Takahashi[1], and N. Saigusa, R. Ide

[1]National Institute for Environmental Studies, Tsukuba, Japan

We report the 4-year (2006-2009) measurements of the ecosystem CO_2 exchange flux (NEE) over a deciduous needle-leaf plantation forest on foothill of the Japanese highest mountain Mt. Fuji. We focus characteristics of temporal variations in (1) NEE and their relationships with environmental factors and phenology, (2) storage structure of CO_2 in forest stand. Firstly, we evaluate year-to-year variations in the seasonal patterns of flux-components and investigate factors controlling the NEE. During growing season, light availability likely affects the photosynthetic uptake of CO_2 at the site. We found significant difference in length of growing season among the years. The difference is mainly due to the difference in timing of progress of autumnal coloring of leaves. Timing of starting autumnal coloring of leaves is highly depending on the timing when the daily-lowest temperature becomes less than 10-deg C. Secondly, we investigate the characteristics in short-term and long-term variation of the CO_2 storage structure in the forest stand. The wind system of the site was entirely dominated by northward valley wind in daytime and southward mountain wind in night time. During the time when wind direction makes turns soon after the sunrise, we often find dead halt of air-mass around the canopy in the stable vertical temperature gradient. Under the condition, prominent drawdown of [CO_2] (concentration of CO_2) around canopy layer is frequently observed. This drastic transition of the [CO_2] storage structure is of particular interest in the diurnal cycle of the stand-scale CO_2 exchange between the ecosystem and atmosphere.

CONTINUOUS SOIL CO_2 CONCENTRATION MEASUREMENTS IN TAKAYAMA SUPERSITE AND THEIR IMPLICATIONS

Seiichiro Yonemura[1], Masayuki Yokozawa[1], Gen Sakurai[1], Ayaka M. Kishimoto[1], Yasuto Shirato[1], Shohei Murayama[2], Kentaro Ishijima[3], Mi-Sun Lee[4*], Toshiyuki Otsuka[4], and Hiroshi Koizumi[5]

[1] National Institute for Agro-Environmental Sciences, Tsukuba, Japan
[2] National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan
[3] Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan
[4] Gifu University, Gifu, Japan
**Now at National Park Research Institute, Namwon-si, Korea*
[5] Waseda University, Tokyo, Japan

At Takayama station which is a most-pronounced super-site among the flux sites in Japan, extensive measurements have been conducted more than a decade ago. Besides automatic measurements of soil respiration (soil surface CO_2 flux), we set small NDIR CO_2 sensors (Vaisalla, GMP220) that enable continuous measurements, into soil at soil depths of 0, 5, 10, 20, and 50cm below the flux tower in 1-ha site in Takayama site in 2005 for the understanding of soil CO_2 dynamics and the measurements are still going on. The CO_2 sensors were calibrated in-situ by periodically introducing standard CO_2 gases. We converted the 10 min- or 20 min-interval original data into hourly, daily, and month data. Diurnal variation of soil CO_2 concentrations were found in summer seasons, however the variations were much smaller than those measured in an agricultural field (Yonemura et al., 2009).

Seasonally, soil CO_2 concentrations were larger with increasing soil depth; in summer they were from 2000 ppm to 10000 ppm (Fig. 1) and in winter under snow they were from 2000 ppm to 3000 ppm. Soil CO_2 concentrations showed sinusoidal yearly variation with maxima in July, being similar to soil CO_2 fluxes and minima in the late autumn and the early spring winter seasons. Soil CO_2 concentrations positively corresponded with soil moisture in day or week time-scale. This contrasts with CO_2 concentrations values measured in agricultural fields (Yonemura et al., 2009). This is consistent with results from incubation experiments with controls in soil moisture. However, seasonal CO_2 concentration peaks were found in snowy seasons. The concentrations in snowy seasons were largely correlated with soil depth and showed negative relation with wind speed. Winter time CO_2 concentrations well corresponded with snow depth but were influenced by wind.

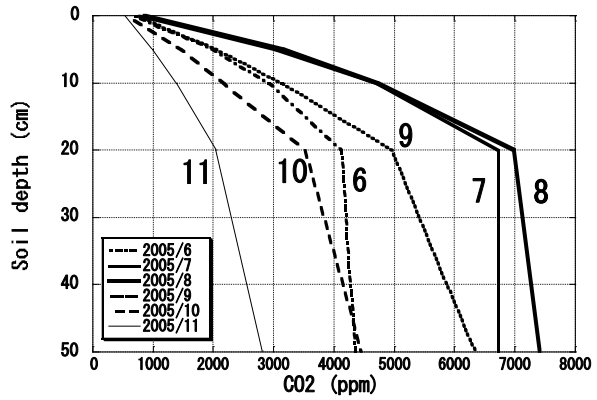


Fig.1 Monthly CO2 concentration profiles in summer 2005

The averaged residence time of CO_2 in soil were calculated by dividing soil CO_2 amount by soil respiration. The residence time was estimated to be between 1.5-2 hours, showing the contribution of emission of CO_2 in the shallower surface layers. The residence time was larger under lower CO_2 concentrations, which shows that more CO_2 is emitted from deeper layers under lower soil moisture. We are further analysing the CO_2 profile data by a systematic model, using not only soil CO_2 concentration data but also data of gas diffusivity and soil CO_2 temperature and moisture dependence obtained by incubation experiments.

PATTERN IN ROOT RESPIRATION RATES WITH THEIR MORPHOLOGICAL

TRAITS IN 13 TREE SPECIES IN TROPICAL FOREST

Naoki Makita[1], Yoshiko Kosugi[1], Masako Dannoura[1], Satoru Takanashi[2], Kaoru Niiyama[3], Abd Rahman Kassim[4], and Abdul Rahim Nik[4]

[1] Graduate School of Agriculture, Kyoto University, Kyoto 606-8502, Japan
[2] Forestry and Forest Products Research Institute (FFPRI), Ibaraki 305-8687, Japan
[3] Tohoku Research Center, FFPRI, Morioka 020-0123, Japan
[4] Forest Research Institute Malaysia, Kepong, Kuala Lumpur 52109, Malaysia

Tree roots constitute a large fraction of annual net primary production, resulting in a large flux of carbon (C) and nutrients into the belowground system. The root systems are composed of different diameters and heterogeneous physiological traits. There is now considerable evidence that difference in root diameter size influence the respiration. However, current understanding of the patterns and controls of root respiration from small fine roots to large coarse roots across species is limited, because previous studies focused on specific diameter sizes and specific species. Here, we attempted to clarify the species-specific respiration rates of fine roots (<2 mm diameter; n=125) and coarse roots (2–269 mm diameter; n=175) of 13 species in 14 trees differing in tree height and age in a primary tropical rainforest. The variability in respiration rates was examined in relation to mean root diameter (*D*; mm) of various diameter sizes and the root tissue density (RTD: g cm^{-3}) and specific root length (SRL: m g^{-1}) of fine roots. This study site was located in the Pasoh Forest Reserve (2°59'N, 102°19'E) of the Forest Research Institute Malaysia in Peninsula Malaysia. Root sampling was conducted from 31th Jan. to 6th Feb. 2010. Each root segment was carefully isolated from the soil and then gently washed. The root respiration rate was measured using a closed dynamic chamber system equipped with an infrared gas analyzer (LI-840). The most suitable chamber was selected from nine size patterns (volume=0.12, 0.21, 0.34, 0.48, 0.94, 1.45, 2.17, 11.60, or 22.50 L). Following the respiration measurements, the root length, volume, and mean root diameter of all samples <2 mm in diameter were measured using WinRHIZO Pro 2007a. The roots >2 mm in diameter were measured manually using a vernier scale and ruler. After measuring the morphological traits, all root segments were dried at 70°C for 48 h and weighed. These procedures were repeated for 300 samples from 14 trees. Coarse root respiration rates increased with decreasing D, resulting in significant relationships between root respiration and diameter across species. A model based on a radial gradient of respiration rates of coarse roots simulated the exponential decrease in respiration with diameter. We found a high correlation between the estimated and measured respiration rates for coarse roots. Conversely, when the model was fitted to the data from coarse roots, the measured respiration rate of fine roots was higher than the estimated respiration rate of fine roots. This result suggests that fine roots, which appear to be analogous to leaves, have additional different functions than coarse roots. Fine root respiration rates were much higher and more variable than those of larger diameter roots. For fine roots, the mean respiration rates for each species increased with decreasing D. The respiration rates of fine roots declined markedly with increasing RTD and increased with increasing SRL, which explained a significant portion of the variation in the respiration among the 14 tree species examined. These results indicate that coarse root respiration follows a basic relationship with D across species and that most of the variation in fine root respiration among species is explained by D, RTD, and SRL. Our findings provide evidence of the generality and specificity of root respiration from very fine roots to coarse roots in relation to their morphological traits across species. Examining root respiration is a time consuming and difficult endeavor because it requires excavating and identifying the roots of each species in mixed tropical forest. In practice, if it is possible to use physio-morphological traits beyond species, root respiration could be more easily and quickly scaled up to the forest stand level, such as by using the proportions of each root biomass distribution for fine and coarse roots in the field.

NORTHERN JAPAN'S COOL-TEMPERATE FOREST REACHES A CARBON COMPENSATION POINT 7 YEARS AFTER CLEARCUTTING

M. Aguilos[1], K. Takagi[2], K. Fukuzawa[2], N. Saigusa[3], T. Murayama[4], Y. Fujinuma[5] and K. Sasa[2]

[1]*Graduate School of Environmental Science, Hokkaido University, Sapporo, 060-0809 Japan*
[2]*Field Science Center for Northern Biosphere, Hokkaido University, Sapporo, 060-0809 Japan*
[3]*Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, 305-0056 Japan*
[4]*Research and Development Department, Hokkaido Electric Power Co., Inc., Ebetsu, 067-0033 Japan*
[5]*Department of Environmental Management, Tottori University of Environmental Studies, Tottori, 689-1111 Japan*

A mixed-forest in Northern Japan, which had been a weak carbon sink (net ecosystem exchange (NEE): -0.44 tC ha^{-1} yr^{-1}) was disturbed by clear cutting and was replaced with hybrid larch plantation. In order to predict the impact of such disturbance and determine the length of time to reach the carbon compensation point following harvest, a 10-year (2001-2010) eddy covariance measurements of CO_2 fluxes coupled with the biomass determination of understory *Sasa* dwarf bamboo and the planted larch saplings were employed. When trees in the study site of 13.7 ha were clear cut in 2003, the ecosystem abruptly became a large carbon source. NEE reached 5.69 tC ha^{-1} yr^{-1} in 2003 and 4.95 tC ha^{-1} yr^{-1} in 2004 yet dropped to as little as 1.53 tC ha^{-1} yr^{-1} in 2005 then gradually decreased until GPP and RE were almost balanced with only 0.28 tC ha^{-1} yr^{-1} of NEE in 2009. Finally in 2010, the ecosystem gained back its status as carbon sink (NEE, -0.48 tC ha^{-1} yr^{-1}). Total GPP, RE, and NEE 7 years after the disturbance (2003-2009) were 64.5, 79.2, and 14.7 tC ha^{-1}, respectively. The NEE value could be as much as 77% of the carbon transferred out of this ecosystem as timbers in 2003 (19 tC ha^{-1}). *Sasa*, which mainly contributes to a higher GPP blanketed the forest floor and gained a biomass of ca. 20 tC ha^{-1} within 7 years, while larch sapling only obtained ca. 0.60 tC ha^{-1} at the same period. These results also indicate that soil (including roots and residuals after tree harvesting) had been a large carbon emitter (ca. 36 tC ha^{-1}) during the period.

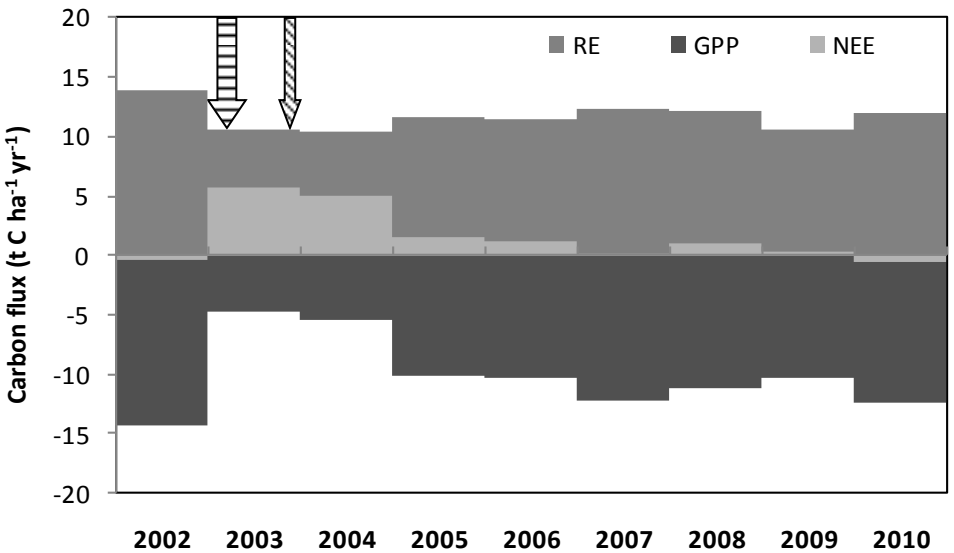


Figure 1. Interannual variability of gross primary production (GPP), ecosystem respiration (RE), and net ecosystem exchange (NEE). Arrows with horizontal and diagonal hatches represent periods of clear cutting and the strip-cutting of *Sasa* and larch planting, respectively.

SPATIAL AND TEMPORAL DISTRIBUTION OF LIGHT USE EFFICIENCY IN CHINESE TERRESTRIAL ECOSYSTEM

Yanni Gao[1, 2], and Guirui Yu[1]

[1] Synthesis Research Center of Chinese Ecosystem Research Network, Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China
[2]Graduate University of Chinese Academy of Sciences, Beijing 100049, China

Light use efficiency (LUE) represents the ratio of light energy converting to plant biochemical energy. It is also a key parameter in ecosystem production efficiency models which were drove by remote sensing data. Clarifying the spatial and temporal distribution of light use efficiency in Chinese terrestrial ecosystem is important to improve Chinese production efficiency model and evaluate China carbon budget. In this paper, the observed data of ChinaFLUX that contained forest, grasslands and croplands ecosystems were used to gain gross primary productivity (GPP) and absorbed photosynthetically active radiation (APAR). Then, the ratios of both were used to compute statistic parameters of light use efficiency on day, month, and year scales. As a result, the spatial and temporal pattern of light use efficiency was analyzed in Chinese terrestrial ecosystem. Furthermore, we discussed the possible approaches to improve the light use efficiency model.

THE RELATION OF DROUGHT AND THERMAL STRESSES WITH INTER-ANNUAL NDVI VARIABILITY IN DRYLAND ECOSYSTEM

Nayoung Do[1], Sinkyu Kang

[1]*Dept. of Environmental Science, Kangwon National University, Chuncheon, Republic of Korea*

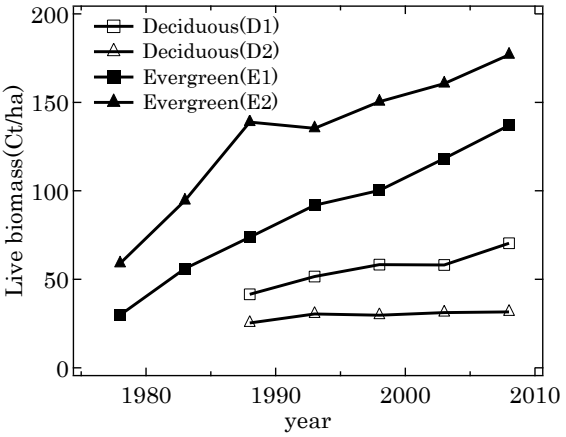
Severe drought and summer thermal stresses in dryland ecosystem can result in reduction of vegetation productivity or biomass as well as alteration of species composition, which might increase ecosystem vulnerability on land degradation. Previous studies have commonly used precipitation data to assess the effect of drought stress. However, soil moisture would be better water-related environmental variable than precipitation for explaining vegetation eco-physiological response to drought stress through its determinant effect on stomata behavior. In this study, we investigated relations between ecosystem biophysical and climatic variables derived from satellite observations and their impacts on inter-annual NDVI variability in Mongolia over the last 10 years. Our specific purposes are to examine spatial and temporal patterns of vegetation indices, land surface temperature (LST), soil moisture (SM), and air temperature; and to understand relations among the biophysical and climatic variables. Various satellite datasets were prepared, including MODIS NDVI, air temperature and LST, and AMSR-E soil moisture data from 2000 to 2009. Especially, MODIS air temperature and AMSR-E SM data have potentials to examine the relations between drought or summer stress and vegetation productivity across dryland ecosystem. In addition, we collected monthly temperature and precipitation data from 70 weather stations in Mongolia. We set extreme drought and thermal stress cases for the lowest 10% of SM and for the top 10% of LST and air temperature, respectively, which were compared with inter-annual NDVI anomalies. Our results are that regions with higher SM but lower LST showed higher NDVI and vice versa. Across 70 weather stations, summer-time vegetation index showed good positive and negative correlations with SM and LST, respectively. Our results indicate that although precipitation explains well NDVI inter-annual and spatial variations, AMSR-E SM can be an alternative measure of precipitation if the data is not available. Though it is less distinct than SM, satellite-driven LST also provides useful information on dryland vegetation dynamics. In this presentation, we will show the relation of summer stress with vegetation productivity using MODIS-derived air temperature and NDVI data.

LONG TERM MONITARING OF LIVING AND DEAD PLANT BIOMASS IN 50YEARSOLD DECIDUOUS AND EVERGREEN FORESTS

Y.Wada[1], Y.Kominami[2], K.Yoshimura[2], M.Dannoura[1], C.Uematsu[3], and T.Kira[3]

[1]Graduate School of Agriculture Kyoto University, Kyoto, Japan
[2]Kansai Research Center, Forestry and Forest Products Research Institute, Kyoto, Japan
[3] Graduate School of Science Osaka City University, Osaka, Japan

NEP is expressed as the total amount of increments in live and dead plant biomass and lost by herbivory minus heterotrophic respiration, and is controlled not only by environmental conditions (e.g. climate) but also by biological conditions (e.g. forest type, stand density) NEP is highly dependent on increment in live biomass. Therefore we conducted long term monitoring of living and dead plant biomass in 50 years old deciduous and evergreen broad-leaved stands. The study has been conducted at Botanical Garden, Faculty of Science, Osaka City University, Osaka, central Japan. The annual mean temperature was 15.4℃. Annual mean precipitation from 1978 to 2010 was 1603.8mm. In the site, several types of demonstration forests were planted then tree DBH & height were measured every five years since 1978 on evergreen broad-leaved stands, and since 1988 on deciduous broad-leaved stands. Adjacent 2 evergreen broad-leaved stands and 2 deciduous broad-leaved stands were selected, plant biomass- stand density relationship and mortality rate in every tree size class were compared, differing from each other in forest type and stand density. We calculated stand density and annual mortality rate from the repeated census data. Mortality rate (MR) was estimated following the equations: $MR=\{1-(N_s/N_0)^{1/5}\}\times 100$ where N_s= survived stems in tree size class ; N_0= number of original stems in tree size class. The results of the analyses on the plant biomass-stand density relationship showed that mean plant biomass of deciduous forests were always smaller than that of evergreen stands in any stand density. In evergreen stands, the MR became lower as tree size classes became larger. In deciduous stands, the MR in small and large tree size classes were equivalent. It is likely that large size tree died as frequently as small size tree in deciduous stands. In case of the same stand density, mortality of deciduous was larger than that of evergreen stands. For the reason of differences of increment in plant biomass and MR in the composition of trees, plant biomass per ha of deciduous stands were smaller than that of evergreen stands (figure), and therefore the plant biomass per ha was determined by biological condition even if the stands were in the same environmental condition. Differences of increment in plant biomass and MR in the composition of trees suggest that it is important to consider the composition of trees in case of calculating CO_2 uptake.



Trajectories of live biomass in the four broad-leaved forests since 1978(E1,E2) and 1988(D1,D2).

Acknowledgments. This study was supported by KAKENHI no. 21601004and Nippon Life Insurance Foundation.

PRELIMINARY STUDY ON LONG-TERM TEMPERATURE TRENDS BETWEEN MT. ALI AND MT. JADE, TAIWAN.

Yen-Jen Lai[1,4], Tsong-Hue Wey[1], Cheng-Sheng Chang[1], Biing-Tzong Guan[2], Chyi-Rong Chiou[3], and Ya-Nan Wang[2]

[1]Assistant Researcher, Experimental Forest, National Taiwan University
[2]Professor, School of Forestry and Resource Conservation and Director of Experimental Forest, National Taiwan University
[3]Associate Professor, School of Forestry and Resource Conservation and Director of Experimental Forest, National Taiwan University
[4]Corresponding Author, No.12, Sec.1 Chien-Shan Rd. Jushan Township, Nantou, Taiwan; E-mail: alan@exfo.ntu.edu.tw

IPCC's AR4 indicated air temperature in 2000 was about 0.8°C warmer than that in 1950s in Asia regions. The global warming impact could be different from region to region and high mountain regions are some of the most sensitive areas where need to be monitored attentively due to bio-diversity impact issue. Moreover, the long-term temperature trends on the high mountain area in Taiwan are still open to question. Moving average is currently one of the effective methods for trend analysis; however, except long-term trend, no more information could be obtained for further analysis from this method. This study tried to use a new algorithm, Ensemble Empirical Mode Decomposition (EEMD) (Huang et al., 1998; Wu and Huang 2005, 2008), to decompose climatic signal into number of components, which are collections of intrinsic mode functions (IMF) and each IMF stands for one impact factor/cycle (e.g. ENSO, Sunspot or lunar cycles). The last residue is the long-term trend of the signal. Based on IMFs and last residue, we would have a comprehensive grasp of the long-term climatic signal. Under this preliminary study, the last residues of climatic signals at two meteorological stations on the high mountain regions in central Taiwan are compared: one is on Mt. Jade North Peak (Elev. 3845m), another is on Mt. Ali (Elev. 2470m). These climatic signals include monthly-mean air temperature (MAT), monthly-mean maximum air temperature , monthly-mean minimum air temperature, and monthly-mean diurnal air temperature range (DTR) which are highly related to niche information and bio-climate envelope of native species. The distance between these two stations is only 15 km, but the results showed the long-term climatic trends were various on Mt. Ali - Mt. Jade area. MAT rose quicker in winter than in summer from both sites, about 1°C higher than the baseline (1950s) in wintertime. Extreme temperature warmer/cooler speeds were different around these two sites. The trends of the monthly-mean DTR were smaller on Mt. Ali but larger on Mt. Jade North Peak. The trends indicated changes of the niches were quick, complex and difficult to be adapted for some plants and animals. Moreover, these inconsistent trends between two sites could limit their migrant space and force some native species to face extinct threat faster than we expect because of global warming. The results also indicate EEMD is a good trend analytic method for most cases although in a few cases, it does get wrong results and have room to be improved. In addition, the IMFs of all analytic results were also worth to be further studied in the future.

COUPLING A RECTANGULAR HYPERBOLA MODEL WITH DYNAMICS OF LEAF AREA INDEX TO COMPUTE HALF-HOURLY CANOPY GROSS PRIMARY PRODUCTION RATES OF RAINFED MAIZE

Sun Jing-Song[1, 3], and Zhou Guang-Sheng[2, 1,*]

[1]*State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing, China*
[2]*Chinese Academy of Meteorological Sciences, China Meteorological Administration, Beijing, China*
[3]*Graduate University of Chinese Academy of Sciences, Beijing, China*

Leaf area index (*LAI*) of maize and abiotic factors (temperature, water, solar radiation) can change significantly during growing season and affect carbon budget of terrestrial ecosystems. Previous studies suggested that there is a rectangular hyperbolic relationship between gross primary production (*GPP*) and photosynthetically active radiation (*PAR*). However, a fluctuation of the parameter A_{max} was observed in maize-based agroecosystem in southwestern Liaoning province, China, at different stages of maize growth from 2004 to 2008. The objective of this study was to reveal the driving factors of this parameter at different times during the growing season. Multiple linear regression analysis showed that there was a statistically significant between A_{max} and *LAI*: A_{max} = a *LAI* + b(a=0.64,b=0.15, R^2=0.74,*P*=0.002). Thus, a modified model $GPP = \frac{\alpha PAR(aLAI + b)}{\alpha PAR + (aLAI + b)}$ was developed to estimate half-hourly canopy gross primary production (*GPP*) rates of maize. Our results demonstrate that the new model improve accuracy in simulating *GPP* throughout the growing season.

FLUXPRO AS A QUALITY CONTROL AND QUALITY ASSURANCE SYSTEM FOR EDDY COVARIANCE MEASUREMENT

Wonsik Kim[1], Hyeong-Ho Seo[2], Daisuke KOMORI[3], Keisuke Ono[1], Masayoshi Mano[1], and Akira Miyata[1]

[1]National Institute for Agro-Environmental Sciences, Tsukuba, Japan
[2]Agricultural Research Center for Climate Change, Jeju, Korea
[3]The University of Tokyo, Tokyo, Japan

FluxPro which was a realtime flux monitoring and forecasting system based on a data assimilation technique throughout the fusion of an eddy covariance (EC) measurement and a land surface model was launched out over internet (http://kings.niaes2.affrc.go.jp/) in 2009. It has been tested at some agricultural fields as the unique system not only to detect the optimizing condition of photosynthesis (PS) and evapotranspiration (ET) but also to control the irrigation timing and amount keeping those suitable conditions when harsh weather events are arisen. In a little outcomes, the effectiveness of FluxPro was somewhat proved as a continuous and prompt alarm system and a precise and reliable information system about PS and ET. However, FluxPro has little information concerning the capability of quality control and quality assurance (QCQA) as one of the EC monitoring systems in spite of whose high performance about uncertainty analysis. In this presentation, we will show the reliability of FluxPro based on EC tolerance (Kim et al., 2010a, 2010b) against classical analysis by frictional velocity over Monin-Obukhov similarity theory.

A NEW GAP-FILLING STRATEGY FOR EVAPOTRANSPIRATION

Minseok Kang[1], Joon Kim[2], Hyojung Kwon[1], Jun Asanuma[3], Minoru Gamo[4], Takashi Hirano[5], Yue-Joe Hsia[6], Hiroaki Kondo[4], Ayumi Kotani[7], Yojiro Matsura[8], Takeshi Ohta[7], Nobuko Saigusa[9], Kentaro Takagi[10], Ichiro Tamagawa[11], Susumu Yamamoto[12], Guirui Yu[13]

[1]National Center for Agro-Meteorology, Seoul National University, Seoul, Korea
[2]Department of Landscape Architecture & Rural Systems Engineering, Seoul National University, Seoul, Korea
[3]Terrestrial Environment Research Center, University of Tsukuba, Tsukuba, Japan
[4]National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan
[5]Graduate School of Agriculture, Hokkaido University, Sapporo, Japan
[6]College of Environmental Studies, National Dong Hwa University, Hualien, Taiwan
[7]Graduate School of Bioagricultural Sciences, Nagoya University, Nagoya, Japan
[8]Department of Forest Site Environment, Forestry and Forest Products Research Institute, Tsukuba, Japan
[9]Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Japan
[10]Field Science Center for Northern Biosphere, Hokkaido University, Hokkaido, Japan
[11]River Basin Research Center, Gifu University, Gifu, Japan
[12]Graduate School of Environmental Science, Okayama University, Okayama, Japan
[13]Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China

Under wet canopy conditions, surface conductance becomes infinity and evaporation approaches its potential rate. Even though the characteristic of energy partitioning under wet canopy condition is different to that under dry condition, current gap-filling method for evaporation is usually applied without distinction of canopy wetness condition. The previous analysis in Gwangneung deciduous and coniferous forest reported that wet canopy evaporation (E_{WC}) estimated by a traditional modified lookup table (MLT) based gap-filling consistently and significantly underestimated those estimated using E_{WC} numerical model (i.e., the algorithm of Variable Infiltration Capacity land surface model (VIC LSM)) due to the failure of considering aerodynamic coupling, advection of sensible heat, and heat storage. Accordingly, a different gap-filling strategy based on canopy wetness conditions was proposed as follows. As a first step, calculate the intercepted canopy water (W_c) using the E_{WC} algorithm of VIC LSM. Then, fill in all the missing gaps using the gap-filling method (e.g., MLT) in which only the data from dry canopy conditions (i.e., when $W_c = 0$). Then, for wet canopy conditions (i.e., when $W_c > 0$), replace the gap-filled data with the sum of E_{WC_VIC} and the gap-filled data multiplied by $1 - (W_c/S)^n$ (i.e., contribution from transpiration; where S is the canopy storage capacity, and n is an empirical coefficient). The evapotranspiration (ET) data sets from other flux sites in Asia deserve further scrutiny regarding the potential biases in E_{WC}. The application of the proposed new gap-filling strategies would improve the reliability of the gap-filled ET data sets. In this study, we tested application of the new gap-filling strategy to 22 forest sites in CarboEastAsia database (i.e., CBS, QYZ, BNS, LSH, BKS, PDF, TSE, FJY, MBF, MMF, SMF, TKC, TKY, TMK, GDK, GCK, SKT, TUR, YLF, YPF, MKL, SKR; 11 coniferous forests, 5 tropical forests, 4 deciduous forests, and 2 mixed forests). According to the preliminary result, the annual E_{WC} gap-filled by the new strategy increased by about 30 ~ 60% compared with that by MLT method. The contribution of E_{WC} to ET was about 15 ~ 20%. We are dealing with the remained data sets, and analyzing the seasonal and inter-annual variation of ET and E_{WC}.

IN SITU MEASUREMENT OF CO_2 EFFLUX FROM LEAF LITTER USING AUTOMATED CHAMBER SYSTEM

M. Ataka[1], Y. Kosugi[1], Y. Kominami[2]

[1] *Faculty of Agriculture, Kyoto University, Japan*
[2] *Kansai Research Center, Forestry and Forest Products Research Institute, Kyoto, Japan*

Soil respiration is sum of CO_2 efflux from various components (e.g. root for autotrophic respiration; leaf and root litter, and SOM for heterotrophic respiration). Each respiration process has specific characteristics responding to environmental conditions (e.g. water condition, temperature). Especially, heterotrophic respiration is highly affected by wetting and drying event during and after rainfall event. The greatest temporal variability in water condition may occur in or near the A_0 layer, and this will affect the variation in leaf litter respiration (R_{LL}) and therefore soil respiration. A better understanding of temporal changes in R_{LL} to rainfall is required to evaluate heterotrophic and soil respiration at the ecosystem scale. We measured R_{LL} using automated chamber system to examine response of R_{LL} to wetting and drying event due to rainfall and compared with the response of soil respiration. Observations were performed at Kiryu Experimental Watershed (KEW) located in central Japan (34° 58' N, 136° 00'). The forest was dominated by *Chamaecyparis obtusa Sieb*. Et zucc. (Japanese cypress, an evergreen conifer). Forest soil originated from weathered granite is immature soil. We used leaf litter of *Chamaecyparis obtusa Sieb*. for respiration measurement. Measurement period is from March to September 2011. To examine temporal changes in R_{LL}, we used automated dynamic chamber system. We used four chambers to respectively measure CO_2 efflux from leaf litter, mineral soil, soil and soil without leaf litter. For leaf litter and mineral soil chamber, we replaced organic soil inside chamber with weathered granite soil of an equal depth and the acrylic board was buried just below the base of chamber to prevent from other CO_2 efflux (e.g. root and soil organic matter) (Fig.1). We measured air temperature inside the chamber, soil temperature (5cm depth) and soil water content (5cm depth), and installed leaf wetness sensor. Leaf wetness sensor was used to detect starting point of rainfall. During non-rainy day, R_{LL} showed a diurnal pattern, which is corresponding to the diurnal changes in temperature. R_{LL} was beginning to increase within a few hours from starting time of rainfall and showed peak values during rainfall (fig.2). The rate of increase and decrease of R_{LL} during rainfall were higher than that of soil respiration. The responses of each component of soil respiration to rainfall would be different.

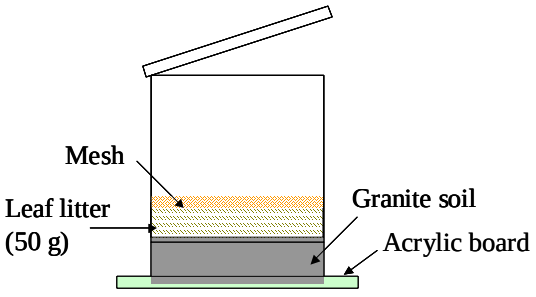


Fig.1 Illustration of chamber for leaf litter respiration measurement

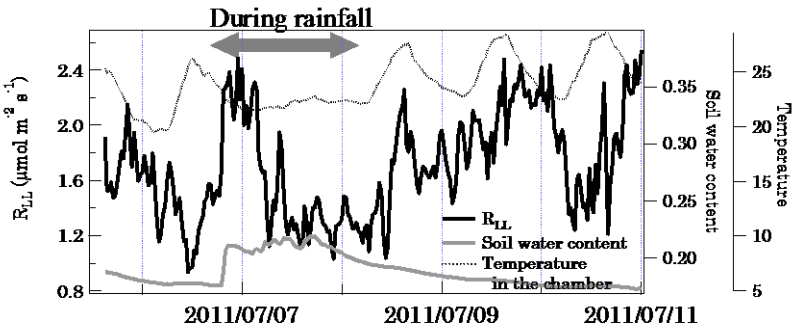


Fig 2. Temporal changes in R_{LL}

THE ATTENUATION AND CORRECTION FOR PHOTOSYNTHETICALLY ACTIVE RADIATION LONG-TERM OBSERVATIONS WITH QUANTUM SENSOR IN CHINAFLUX FOREST SITES

Zhilin Zhu[1], Xiaomin Sun[1], Gurui Yu[1], Xuefa Wen[1], Yiping Zhang[2], Shijie Han[3], Junhua Yan[4], and Huimin Wang[1]

[1]*Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing* 100101, *China*
[2]*Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun* 666303, *Yunnan, China*
[3] *State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang* 110016, *China*
[4]*South China Botanical Garden, Chinese Academy of Sciences, Guangzhou* 510650, *China*

Photosynthetically Active Radiation (PAR) plays an important role in ecosystem carbon flux research. In order to calculate the monthly or annual sums of CO_2 flux (F_c), for example, any time F_c must be known first. while F_c maybe missed in some daytime due to instruments and other causes, the first step of gap-filling is to establish the non-linear model between good data of F_c and PAR., and then to fill the missed data with the modeled data. So, the data quality of PAR will directly affect the results of missed F_c as well the annual sum of CO_2 flux. To check whether the performances of PAR quantum sensor (Li-190SB, Li-Cor, USA) were attenuated or not in long-term and continuous observation, the changes of photosynthetically active radiation in 4 ChinaFLUX forest sites (Changbaishan, Qianyanzou, Dinghushan and Xishuangbanna) were analyzed. Especially, the ratios of PAR to global radiations (measured with high accuracy pyranometer CM11, Kipp & Zonen) during 6 years (2003--2008) were compared. The result showed that there was obvious performance attenuation for quantum sensors at all 4 forest sites. The mean annual attenuation rate was about 4% (see table). To correct the attenuation and errors, a post-correcting method for PAR observations was attempted to give out. The basic equation is $PAR_{cor} = PAR_m /[1- (n\text{-}1)a]$, where PAR_m and PAR_{cor} are measured and corrected photosynthetically active radiation, n is the accumulative months from the first month, a is the monthly attenuation rate as below. After correction, it basically eliminates the effect caused by the quantum sensor's performance attenuation due to long-term field measurement.

Table 1. Monthly and annual attenuation rate of PAR in 4 forest sites.

Site name	Monthly attenuation rate （%）	Annual attenuation rate （%）
Changbaishan	0.3	3.5
Qianyanzhou	0.3	3.6
Dinghushan	0.4	4.7
Xixhuangbanna	0.4	4.6

ESTIMATING OF SENSIBLE HEAT AND LATENT HEAT FLUXES BY COUPLING SURFACE-LAYER SCINTILLOMETER AND EDDY-COVARIANCE SYSTEM OVER A FORESTED HILLY TERRAIN

Chao-Jung Fan[1], Jehn-Yih Juang[1], Ya-Nan Wang[2,3], Yen-Jen Lai[3], and Chih-Yuan Hung[3]

[1]Department of Geography, National Taiwan University, Taipei, Taiwan
[2]School of Forestry and Resource Conservation, National Taiwan University, Taipei, Taiwan
[3]The Experimental Forest, National Taiwan University, Nantou, Taiwan

In the past decade, eddy-covariance (EC) technique has been widely applied in many study sites to quantify the exchange of scalars, momentum, and energy components between the terrestrial ecosystem and atmosphere. However, due to the limitation and fundamental assumptions of EC methods, the estimation of area-averaged fluxes over a complex terrain is experiencing significant uncertainty. To systematically quantify the area-averaged energy fluxes, and integrate the relationship between the tower-based EC measurement and corresponding land-surface parameters over a typical forested hilly terrain in Taiwan, in this study, a surface-layer scintillometer (SLS) system with a path length of 60 m was placed in a planted broad-leaf forest at Xitou flux tower in Central Taiwan. The SLS system applies Monin-Obukhov Similarity Theory (MOST) to estimate the area-averaged sensible heat flux by linking the variances and the covariances of the laser beam amplitude within the path length between the laser transmitter and receiver. Therefore, it provides a better spatial representative than conventional tower-based EC results. In addition to compare the results between EC and SLS systems, in this study, the parameterization of the land-surface properties, such as aerodynamic conductance, Bowen ration, frictional velocity, and surface roughness over a larger area of a hilly terrain will be further quantified. This information could sufficiently offer a better understanding to scale up the EC tower measurement to the ecosystem scale over a hilly terrain.

MODELING SOIL RESPIRATION OF TROPICAL PEAT FOREST

R. Hirata[1], T. Hirano

[1]Hokkaido University, Sapporo, Japan

While tropical peat forest occupies 0.25% of surface area on globe, it accounts 3% of soil organic carbon on earth (Hergoualc'h and Verchot, 2011). Tropical peat forest, which forest grows on peat which depth is from 1 to 10 m, spreads in Southeast Asia such as Borneo or Sumatra Island. Recently, the area of tropical peat forest is rapidly decreasing because of fire or plantation, and has resulted in large carbon lost. Therefore, carbon management and control for tropical peat forest is very important with the objective of development, conservation and disaster prevention. Ecosystem model is useful for this carbon management. In this study, we has developed soil respiration model, which will be incorporated into ecosystem model. Conventional ecosystem model cannot simulate carbon balance accurately. For instance, ecosystem respiration (RE) provided by Biome-BGC showed opposite seasonal variation with measured RE because of misunderstanding of soil respiration process. Soil respiration process, which has been used in conventional ecosystem model, is controlled by only soil temperature and soil water content. In contrast, CO_2 release from peat is regulated by not only these components but also water table. Therefore, we simulated water table in soil respiration model. We has constructed tank model for simulating water table in tropical peat forest. There are two tanks; one is for unsaturated layer and another is saturated layer. There are one-hole in unsaturated tank and two-hole in saturated tank. Water is stored in each tank and outflow from holes. Input of unsaturated tank is precipitation and outputs of it are evaporation and outflow to saturated tank. Input of saturated tank is outflow from unsaturated tank and outputs of it are lack of evaporation in unsaturated tank and outflow to underground water. Outflow velocity is proportional to the difference between water table and each hole. Water table is converted to water quantity by effective porosity. CO_2 is respired from both unsaturated and saturated tanks regulated by soil temperature and soil water content. CO_2 release is changed by depth of unsaturated and saturated tank. We used meteorological and flux data at Parankaraya site in Kalimantan island, Indonesia for validation of model. Both water table and soil respiration from peat surface are simulated well. However, we need more validation using other data in tropical peat forest. Our next step is incorporating this soil respiration model to ecosystem model for tropical peat forest and trying to simulate carbon balance of tropical peat forest ecosystem.

DEVELOPING A NEW DIAGNOSTICALLY-APPROACH FOR SIMULATING TERRESTRIAL CARBON CYCLE: INTEGRATING RADIATIVE TRANSFER MODEL TO BIOSPHERE MODEL

Takahiro Sasai[1], Kazutaka Murakami[2], Yuko Setoyama[1], Nobuko Saigusa[3], and Kenlo Nasahara[2]

[1]Nagoya University, Nagoya, Japan
[2]Tsukuba University, Tsukuba, Japan
[3]National Institute for Environmental Studies, Tsukuba, Japan

Many diagnostic-type terrestrial biosphere models have ever been proposed for estimating terrestrial carbon fluxes. The models require some vegetation phenology information observed by the satellite sensor, leading that the advantage is to more realistically simulate carbon cycle than other type model such as prognostic-type model and DGVM. The phenology information is based on reflectance and NDVI dataset, and is necessarily converted to fPAR and LAI, to calculate carbon fluxes in the biosphere model, with radiative transfer model and empirical equation. However, the accuracy of the fPAR and LAI data would be still not enough to estimate carbon fluxes at global and regional scale. One of the reasons would be that processes in radiative transfer model are not consistency to the process-based biosphere model. To accurately improve the fPAR and LAI dataset, we need to integrate the radiative transfer model to process-based diagnostic-type biosphere model. It means that satellite observational bias is removed with carbon mass conservation in the process-based model. We propose a new diagnostically approach for simulating carbon cycle by integrating our developed biosphere model, BEAMS (Biosphere model integrating Eco-physiological And Mechanistic approaches using Satellite data) (Sasai et al., 2005, 2011) and new radiative transfer model. BEAMS consists of carbon cycle, hydrology and energy balance submodels. The radiative transfer model is based on the SAIL model (Verhoef, 1984), and is greatly modified with ground observations in Japan. In this study, as first step, after calculating LAI from reflectance data with the radiative transfer model, we try to simulate carbon fluxes with BEAMS by using the LAI data as model input (offline simulation).The time step is 1 month, and spatial resolution is 1km by 1km. The study area is Far East Asia (N30˚, E125˚ - N50˚, 150˚). Spatial variation in the GPP estimation showed low in northern area, and higher towards southern area, suggesting that the spatial variation in GPP would have reasonable trends.

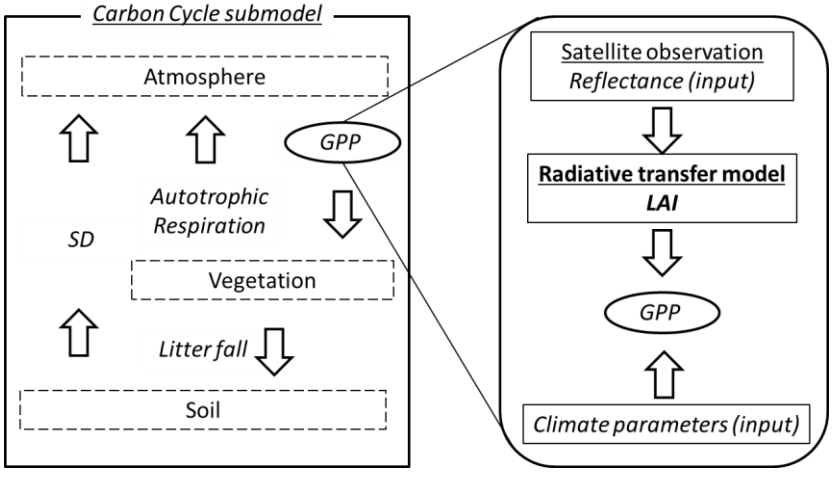


Figure 1. Model structure in a new diagnostically approach.

DETECTION OF IRRIGATION TIMING AND SPATIAL DISTRIBUTION IN THE PADDY RICE FIELDS CONSIDERING LAND COVER HETEROGENEITY USING MODIS IMAGES

Seungtaek Jeong[1], Keunchang Jang[2], Sinkyu Kang[2], Hoonyol Lee[3], and Seokyeong Hong[4]

[1]Dept. Agricultural and Life Science,Chonnam University, Kwangju, Republic of Korea
[2]Dept. of Environmental Science, Kangwon National University, Chuncheon, Republic of Korea
[3]Dept. of Geophysical Science, Kangwon National University, Chuncheon, Republic of Korea
[4]Dept. of Soil&fertilizer, National Academy of Agriculture Science, Suwon, Republic of Korea

Paddy rice fields are a typical feature of land cover types in the Asia region. Numerous researches have been reported that the paddy fields have been continuously expanding during past few years. . Paddy fields have unique biophysical characteristics that rice is grown on flooded soil unlike other fields. Information on the spatial distribution of irrigated paddy fields and timing of irrigation are important to determine hydrological balance, efficiency of water resource, and trace gas emission. Because the information of irrigation is different according to present condition of fresh water, kind of paddy, climatic condition, and availability of agricultural machine in each region, obtaining the information through field observation is difficult. In this study, we detected the information for irrigation in the paddy fields using the Moderate Resolution Imaging Spectro-radiometer (MODIS) sensor on board the NASA EOS Terra satellite. Irrigated paddy rice fields were detected by the combined use of MODIS-based Enhanced Vegetation Index (EVI), Land Surface Water Index (LSWI), and threshold value for LSWI. Previous researches have reported that land cover heterogeneity causes considerable uncertainty of the satellite-based detections .Synthetic Aperture Radar (SAR) satellite images and land cover map produced by Ministry of Environment in Korea were used to improve the detection of irrigated paddy fields in this study. We developed the regression equations for threshold from the result of correlation between land cover heterogeneity in irrigated paddy fields and vegetation indices, and calculated the threshold values which are applied to the irrigation detection algorithm. As a result, the algorithm developed in this study showed improved detection (5-111%) in comparison with previous algorithm. In some areas, the results slightly overestimated than the previous algorithm. When compared between the estimated irrigation dates and the observed dates, 3 study sites showed improved results while 7 study sites showed small difference dates (1-7 days) comparison with the previous algorithm. Error of the estimated irrigation dates was 1-16 days when compared with observed irrigation dates. The developed algorithm has the limit of application that land cover map of high spatial resolution is needed, however, the algorithm will be showed high reliability where the region of small scale and large heterogeneity in the paddy rice fields.

COMPARISON OF CONVENTIONAL OPEN-PATH AND NEWLY-DESIGNED CLOSE-PATH GAS ANALYZERS WITHIN A CLOUD FOREST IN TAIWAN

Chih-Yuan Hung[1], Jehn-Yih Juang[2], Yen-Jen Lai[1], Ya-Nan Wang[1,3], Ming-Jer Tsai[1,3], and Jui-Chu Yu[3]

[1]The Experimental Forest, National Taiwan University, Nantou, Taiwan
[2]Department of Geography, National Taiwan University, Taipei, Taiwan
[3]School of Forestry and Resource Conservation, National Taiwan University, Taipei, Taiwan

Eddy covariance (EC) technique has been widely used to quantify the interactions between the terrestrial ecosystem and atmosphere in many observation sites in the recent years. Based on different designs and applications, the EC instruments could be classified into two major types, the open-path EC system (OPEC), and the close-path EC system (CPEC). Generally speaking, the former is easier to install and maintain. However, the OPEC system is strongly influenced by foggy and rainy weather conditions. Therefore, in order to get more reliable measurements during bad weathers, the CPEC system has been utilized more frequently in many sites although the operation and maintenance of the CPEC system is more complicate. In Taiwan, almost all the flux measurement sites are frequently encountering the problems of rainy and foggy weathers and suffering unsatisfied OPEC measurement results. To get a better estimation of flux measurement, in this study, a newly-designed close-path EC gas analyzer (EC-155, by Campbell Inc.) was installed at Xitou flux tower (23 ° 39'N, 120 ° 47'E, 1100 a.s.l.) in the central Taiwan to sample flux data at a long-term basis, and to compare the results with the OPEC gas analyzer (Li-7500, Licor. Inc.) under all kinds of weather condition. This newly-developed CPEC system can sufficiently reduce the lag time caused by the exhaust tube, and is equipped with a heater and an automatic calibration system. The preliminary result shows that the flux values collected from these two systems under good weather conditions are highly consistent. Under rainy and foggy weather conditions, the EC-155 CPEC system performs much better than the OPEC system. Based on this preliminary result, more comparison between the EC-155 close-path and the conventional Li-7500 open-path gas analyzers will be conducted to show if the new system is more suitability under humid environments.

SIMPLIFIED METHOD OF ESTIMATING PHOTOSYNTHETICALLY ACTIVE RADIATION FROM BASIC METEOROLOGICAL DATA

Y. Mizoguchi[1], Y. Yasuda[2], Y. Ohtani[3], T. Watanabe[4], and K. Yamanoi[1]

[1]Hokkaido Research Center, Forestry and Forest Products Research Institute (FFPRI), Sapporo, Japan
[2]Tohoku Research Center, FFPRI, Morioka, Japan
[3]Department of Meteorological Environment, FFPRI, Tsukuba, Japan
[4]Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan

Photosynthetically active radiation (PAR) is one of the most important parameters in evaluating plant photosynthesis. PAR observations using various types of quantum sensors have been conducted worldwide since commercial sensors became available. However, there are some concerns with the reliability of the PAR data measured by the quantum sensors for the following reasons: instrument differences, individual errors, and aging degradation of the sensor. The studies of estimating PAR also have been conducted because of the lack of PAR data and the demand of widespread evaluation of PAR. Although the simplest method of PAR estimation is to calculate it as a constant ratio of the global solar radiation, this ratio changes according to conditions. Most estimation methods demand the elements of sky condition or the direct / diffuse components in order to reflect atmospheric condition (e.g. Alados et al., 1996). Although these approaches are appropriate and effective, there are few sites where these elements are observed. Therefore other approaches using some meteorological data which are more easily available easier are proposed (Alados et al., 1996; Tsubo and Walker, 2005). Two models proposed by Alados et al. (1996), which enabled PAR estimation with only basic meteorological data, were applied to data sets at four sites in Japan (Table 1). Estimated errors of the data sets were larger than those in Alados et al. (1996) and some of them were more than 5%.Therefore, we developed a new estimating equation with only basic meteorological data; global solar radiation, atmospheric pressure and vapor pressure. Estimated errors by the new approach were within 5% except one data set: Kawagoe 2001, estimated error of Kawagoe 2001 data set was 5.2%. Quantum sensors have a relative error of less than 5% according to sensor specifications and the aging degradation is not negligible (Mizoguchi et al., 2010). Error by our proposed method was around 5% or less. This result suggests that this new approach is a useful method to estimate PAR from the whole sky when it is difficult to maintain the reliability of PAR sensor outputs.

Table 1. Data sets used when developing the new estimating equation for PAR

Sites (AsiaFlux site code)	Locations	Observation periods
Fujiyoshida (FJY)	35°27'N, 138°46'E, 1030m	Jan to Dec, 2007 and 2008
Kawagoe (KWG)	35°52'N, 139°29'E, 26m	Jan to Dec, 2000 and 2001
Appi (API)	40°00'N, 140°56'E, 825m	May to Dec, 2009
Hitsujigaoka	43°00'N, 141°23'E, 150m	Jun to Dec, 2009

CARBON BUDGET OF TROPICAL FORESTS IN SOUTHEAST ASIA AND THE EFFECTS OF DEFORESTATION: AN APPROACH USING A PROCESS-BASED MODEL AND FIELD MEASUREMENTS

M. Adachi[1], A. Ito[1], A. Ishida[2], W. R. Kadir [3], P. Ladpala[4], Y. Yamagata[1]

[1]National Institute for Environmental Studies, 16-2 Onogawa Tsukuba, Japan
[2]Kyoto University 509-3-2 Hirano Otsu, Japan
[3]Forest Research Institute Malaysia, 52109 Kepong, Selangor Darul Ehsan, Malaysia
[4]Department of National Park, Wildlife and Plant Conservation, Chatuchak, Bangkok, Thailand

More reliable estimates of the carbon (C) stock within forest ecosystems and C emission induced by deforestation are urgently needed to mitigate the effects of emissions on climate change. A process-based terrestrial biogeochemical model (VISIT) was applied to tropical primary forests of two types (a seasonal dry forest in Thailand and a rainforest in Malaysia) and one agro-forest (an oil palm plantation in Malaysia) to estimate the C budget of tropical ecosystems in Southeast Asia, including the impacts of land-use conversion. The objectives of the present study were to: (1) clarify the similarities and differences between a wet and dry tropical forest to evaluate the potential applicability of the VISIT model, (2) compare the model simulations of tropical ecosystems with field data and modify the VISIT model accordingly, and (3) evaluate the C budget before and after land-use conversion in Malaysia using the VISIT model. Based on our findings, we discuss the potential applicability of the VISIT model and some problems related to its application in Southeast Asia. The observed aboveground biomass in the seasonal dry tropical forest in Thailand (226.3 t C ha^{-1}) and the rainforest in Malaysia (201.5 t C ha^{-1}) indicate that tropical forests of Southeast Asia are among the most C-abundant ecosystems in the world. The model simulation results in rainforest were consistent with field data, except for the NEP, however, the VISIT model tended to underestimate C budged and stock in the seasonal dry tropical forest. The gross primary production (GPP) based on field observations ranged from 32.0 to 39.6 t C ha^{-1} yr^{-1} in the two primary forests, whereas the model slightly underestimated GPP (26.5–34.5 t C ha^{-1} yr^{-1}). The VISIT model appropriately captured the impacts of disturbances such as deforestation and land-use conversions on the C budget. Results of sensitivity analysis showed that the proportion of remaining residual debris was a key parameter determining the soil C budget after the deforestation event. According to the model simulation, the total C stock (total biomass and soil C) of the oil palm plantation was about 35% of the rainforest's C stock at 30 yr following initiation of the plantation. However, there were few field data of C budget and stock, especially in oil palm plantation. The C budget of each ecosystem must be evaluated over the long term using both the model simulations and observations to understand the effects of climate and land-use conversion on C budgets in tropical forest ecosystems.

EFFECT OF EXCESSIVE N SUPPLY ON WINTER WHEAT PRODUCTIVITY: AN INVESTIGATION OVER LEAF, CANOPY, BIOMASS, AND YIELD LEVELS

Fenghua Zhao[1], Junhua Ma[1], Zhigang Sun[2], Qiang Yu[1,3], Jianlin Wang[4], Zhu Ouyang[1]

[1]*Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China*

[2]*National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Japan*

[3]*Plant Functional Biology and Climate Change Cluster, University of Technology Sydney, Broadway NSW, Australia*

[3]*Qingdao Agricultural University, Chengyang, Qingdao, China*

For high crop yield, excessive nitrogen (N) application prevails in the North China Plain (NCP). To optimize N fertilization, therefore, it is necessary to understand the effect of N supply, especially of excessive N supply, on crop productivity. Prior studies were usually conducted on an individual level. We suppose that an integrated understanding on the effect of N supply on successive levels would be helpful to improve the field N management. In this study, the effect of N supply on winter wheat was investigated at levels from leaf, canopy, biomass, to yield in the NCP. Field experiments were conducted under 5 N levels of 0, 70, 140, 210, and 280 kg N ha^{-1}. Leaf photosynthetic rate (A_{leaf}) and canopy photosynthetic rate (A_{canopy}) were measured at the stages of booting, flowering, and grain-filling. Crop growth rate (CGR) was measured during the stages of setting-flowering and flowering-ripening. Results show that A_{leaf}, A_{canopy}, and CGR have increasing patterns at all stages when N supply increases from 0 to 210 kg N ha^{-1}. When N supply increases from 210 to 280 kg N ha^{-1}, the grain yield (GY) has no significant variation; however, the A_{leaf} and A_{canopy} during the grain-filling stage and the CGR during the flowering-ripening stage decrease. Above results indicate that: 1) the N supply of 280 kg N ha^{-1} is excessive for winter wheat in our field trials, and the suitable N supply is around 210 kg N ha^{-1}; 2) an excessive N supply can decrease the photosynthetic productivity of winter wheat over leaf, canopy, and biomass levels; 3) the negative effect of excessive N supply is readily demonstrated during the stage of grain-filling; 4) A_{canopy} is more capable of detecting the negative effect of excessive N supply than A_{leaf}, CGR, and GY.

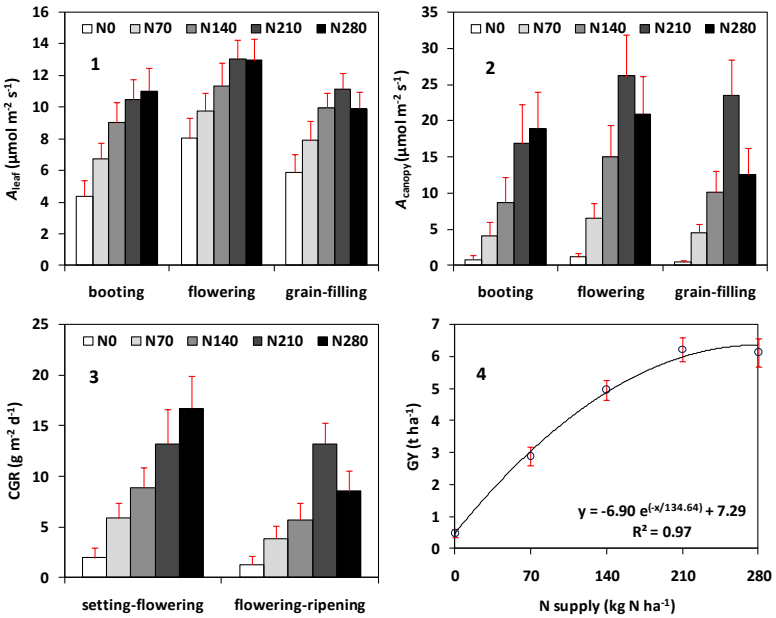


Figure 1. Leaf photosynthetic rate (A_{leaf}) of flag leaves at the stages of booting, flowering, and grain-filling under the N supplies of 0 (N0), 70 (N70), 140 (N140), 210 (N210), and 280 (N280) kg N ha^{-1}.

Figure 2. Canopy photosynthetic rate (A_{canopy}) of N0, N70, N140, N210, and N280 at the stages of booting, flowering, and filling.

Figure 3. Crop growth rate (CGR) of N0, N70, N140, N210, and N280 during the stages of setting-flowering and flowering-ripening

Figure 4. Grain yield (GY) under 5 levels of N supply.

EFFECTS OF MANURE APPLICATION ON ANNUAL CARBON BUDGET AT MANAGED GRASSLAND IN JAPAN

S. Matsuura[1], M. Mano[2], A. Miyata[2], A. Mori[1], M. Hojito[1, 3], H. Sasaki[1], and R. Hatano[4]

[1]National Institute of Livestock and Grassland Science, Nasushiobara, Japan
[2]National Institute for Agro-Environmental Sciences, Tsukuba, Japan
[3]Kitasato University, Towada, Japan
[4]Hokkaido University, Sapporo, Japan

In Japan, livestock husbandry has been supported by enormous imported feed and, as a consequence, livestock excreta have been in surplus. Thus, livestock excreta should properly be composted and returned to grasslands and forage crop fields. Farmyard manure application is expected to increase the amount of carbon accumulated in soils; however it can increase CO_2 emission from soils. The objective of this study was to investigate the effects of manure application on CO_2 flux and annual carbon budget at managed grassland in central Japan. The study was conducted from November 2004 to November 2010 at managed grassland in the National Institute of Livestock and Grassland Science, Nasushiobara, Japan (36°55′N, 139°58′E, 320 m a.s.l.). The annual air temperature and precipitation are 12.0 °C and 1561 mm, respectively. The vegetation is dominated by orchardgrass (*Dactylis glomerata* L.) and Italian ryegrass (*Lolium multiflorum* Lam.). At the grassland two adjoining plots were provided for the experiment: one for applying chemical fertilizer only (F-plot) and the other for applying farmyard manure and chemical fertilizer (M-plot). The amount of applied manure ranged from 30 Mg FM ha^{-1} y^{-1} to 32 Mg FM ha^{-1} y^{-1}, except 15 Mg FM ha^{-1} y^{-1} in 2005. The CO_2 flux was measured with an eddy covariance system, which consisted of a sonic anemometer (CSAT3, Campbell Scientific) and an open-path infrared gas analyzer (LI-7500, Li-Cor). The system was installed at each plot. Net biome production (NBP), which represents carbon budget in grassland ecosystem, was estimated as a sum of the net ecosystem production (NEP), the amount of carbon exported through harvest (H), and that imported through manure application (M): NBP = NEP – H + M. The harvest in the F-plot and the M-plot were 4.9 ± 0.86 Mg ha^{-1} y^{-1} and 5.2 ± 1.1Mg ha^{-1} y^{-1} (mean ± SD), respectively. While there was a significant difference in the harvest among years, there was no significant difference between the plots. The NEP of the plots were 4.7 ± 0.64 Mg ha^{-1} y^{-1} (F-plot) and 4.2 ± 0.69 Mg ha^{-1} y^{-1} (M-plot). There was a significant difference in the NEP between the plots and among years. The values of the NEP in the M-plot were smaller than that in the F-plot. The reduction of the NEP in the M-plot can be explained by the CO_2 emission through manure decomposition. The estimated NBP was significantly higher in the M-plot (2.8 ± 1.4 Mg ha^{-1} y^{-1}) than in the F-plot (–0.18 ± 0.32 Mg ha^{-1} y^{-1}). The NBP in the F-plot was almost zero throughout the study, which shows that the grassland was carbon neutral without organic matter input. Positive values of the NBP in the M-plot indicate that manure application can increase carbon accumulation in the grassland, although the NEP was reduced through organic matter decomposition.

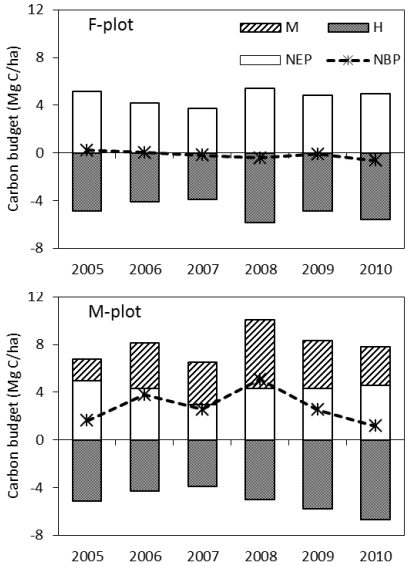


Figure 1. Annual carbon budget and its components in the experimental plots. Positive values indicate that carbon is accumulated in the grassland.

STABILITY IN ECOSYSTEM CARBON BUDGET OF RICE PADDY FIELD BASED ON LONG-TERM FLUX MEASUREMENT

A. Miyata[1], M. Mano[1], K. Ono[1], T. Takimoto[1], G. H. Han[1,2], T. Yamada[1,3], H. Nagai[1], Y. Kobayashi[1,4], H. Yoshikoshi[1,5] and Y. Harazono[1,6]

[1]National Institute for Agro-Environmental Sciences, Tsukuba, Japan
[2]Chungbuk National University, Cheongju, Korea
[3]Global Environmental Forum, Tsukuba, Japan
[4]Tokyo University of Technology, Tokyo, Japan
[5]Yamaguchi University, Yamaguchi, Japan
[6]International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, USA

Twelve years have passed since the tower-flux measurement started at a rice paddy field in Mase, Tsukuba, Japan (Mase paddy flux site) in July 1999, and this is the tenth year since the organized system of long-term measurement got ready to work in 2002 after repeated trial and error at the beginning stage of monitoring at Mase paddy flux site. Because lifetime of monitoring sites in agricultural fields in Asia is generally short (Mizoguchi et al., 2009), the decadal observation at Mase paddy flux site is probably much longer than the average. What is the significance of the long-term measurement in a rice paddy, where, unlike forest and grassland sites, transplanting and harvesting are regularly repeated every year? This is the question always casted on us and also we are wondering to us. Sometimes the question has another form: how many years of observation is enough? The answer may depend on what we need. Here, we show some results on averages of observed fluxes and their inter-annual variations to discuss the issue. From the decadal observation at Mase paddy flux site, it was found that about a half of the net carbon uptake by the paddy field during the growing season was lost abruptly at harvest, and that the remaining half was released to the atmosphere gradually through decomposition of organic matters in the fallow season. Consequently, the net biome production (NBP) was estimated at -0.4±0.7 t C ha^{-1} y^{-1} on average of nine years from 2002 to 2010. This indicates the ecosystem carbon budget of the study site was almost balanced, although uncertainties originating from burning of harvested crop residue and flux measurement in the fallow period using the open-path eddy covariance method still remain. The result of observation is generally consistent with monitoring of carbon content in the top soil and its model simulation. At Mase paddy flux site, we are conducting the measurement by placing the various instruments in a paddy plot, which was managed by the field owner who is a sideline farmer. He cultivates Koshihikari, the most popular rice variety in Japan, and gets average crop yield in the prefecture. The coefficient of variation (CV) of crop yield in nine years was 7%, whereas the CV of the total solar radiation in the growing season was 9% and standard deviation of air temperature averaged over the growing season was 0.9 degree Centigrade. The CVs of the total net ecosystem CO_2 exchange (NEE) and evapotranspiration were both 10%. The CV of gross primary production (GPP) estimated from observed NEE was 5%, but it was reduced to only 2% if we exclude GPP in the 2004 growing season, which had extraordinarily large GPP under conditions of high temperature and plenty of solar radiation. The small inter-seasonal variation in GPP reflects stable Japanese rice production, which is supported by excellent cultivation practices as well as moderate climate conditions. Since we cannot find long-term trends in the fluxes mentioned above, a period of ten years seems to be sufficient for understanding the current state of the fluxes. However, this may not be the case for paddy fields in Southeastern or Southern Asian countries, where rice cultivation seems more vulnerable to inter-annual variations in climate. In addition, even at Mase paddy flux site, the fluxes and accordingly the ecosystem carbon budget may change in future with increases in air temperature and CO_2 concentration, and more probably with changes in management practices, which are influenced by agronomical and socio-ecological factors such as spread of mitigation and adaptation practices for climate change and labor-saving management owing to aging of farmers and an increase in sideline farmers. Continuation of a minimal set of observation is required to detect long-term trends in the fluxes and the ecosystem carbon budget influenced by those factors. The long-term dataset is also favorable to validation of model simulation, but how long is still the problem.

ON DELINEATING ECOHYDROLOGIC PROCESS NETWORKS IN GWANGNEUNG DECIDIOUS FOREST

Juyeol Yun[1], Joon Kim[1], Hyojung Kwon[2], and Jeong Hwa Cheon[3]

[1]Complex Systems Science Lab, Department of Landscape Architecture and Rural Systems Engineering, Seoul National University, Seoul 151-921, Korea
[2]National Center for AgroMeteorology, Seoul National University, Seoul 151-921, Korea
[3]Division of Forest Ecology, Korea Forest Research Institute, Seoul 130-712, Korea

Ecohydrologic systems are open, complex, dissipative systems, which are comprised of various subsystems. These systems are characterized by the couplings of various processes with feedbacks of different scales of time and space. In this study, we adopted a process network method using information flow statistics to delineate the monthly state of the ecohydrologic systems in Gwangneung deciduous forest. A process network is defined as a network of feedback loops and the associated time scales, which describes the magnitude and direction of flow of matter, energy and information between the different variables. We analyzed the time series data of 15 key variables of ecohydrologic systems in Gwangneung deciduous forest in 2008, which are atmospheric pressure, precipitation, net radiation, latent heat flux, sensible heat flux, CO_2 flux, gross primary productivity, ecosystem respiration, air temperature, canopy temperature, vapor pressure deficit, soil temperature, soil water content, wind speed, and wind direction. We computed both mutual information and transfer entropy using the time series data of the above-mentioned variables, produced matrixes for information statistics, and then assembled process network for each month in 2008. In this presentation, we attempted to define the state of ecohydrologic systems by monthly process networks and demonstrate how they adapted to changing environment.

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COMPARING CO_2 SINK STRENGTH OFTWO ADJACENT TEMPERATE FORESTS IN KOREA

BinduMalla Thakuri[1], Joon Kim[2], Hyojung Kwon[3], Chun Jung Hwa[4]

[1]Global Environment Lab, Dept. of Atmospheric Sciences, Yonsei University, Seoul 120-749, Korea
[2]Complex Systems Science Lab, Department of Rural System Engineering, Seoul National University, Seoul 151-921, Korea
[3]National Center for Agro Meteorology, Seoul National University, Seoul 151-921, Korea
[4]Division of Forest Ecology, Korea Forest Research Institute, Seoul 130-712, Korea

Temperate coniferous forest is generally considered as stronger carbon sink compared to deciduous forest because of longer growing season and higher biomass. In Korea, the most representative forest is coniferous forest (~50%). Old and natural forests have been replaced by the secondary regeneration of coniferous forest, and Gwangneung forest is no exception. Because of the proximity (< 1.5 km) of the two Ko Flux towers (coniferous and deciduous forests) Gwangneung study sites provide an excellent opportunity to examine the carbon sink strength of the two different forests under similar weather and climatic conditions and disturbances (e.g., heavy rainfalls and typhoons). We analyzed carbon flux data measured by eddy covariance from 2007 to 2009 at the coniferous forest site (GCK) and deciduous forest site (GDK) in Gwangneung National Arboretum in Central Korea. We also quantify the uncertainty in eddy covariance measurements of carbon flux. Our objectives were to compare the seasonality and inter-annual variability in net ecosystem CO_2 exchange (*NEE*), gross primary productivity (*GPP*), and ecosystem respiration (*RE*) of two forests with different ages, heights, leaf area indexes and soil types. Overall, both annual *GPP* and *RE* were higher for GCK site with average *NEE* of -152 (±97) g C m^{-2} yr^{-1}while that of GDK was -113 (±161) g C m^{-2} yr^{-1}. Both sites showed significant interannual variation in carbon sink strength, which were likely driven primarily by winter temperature, growing season length and different intensity and frequency of precipitation. The interannual variation was relatively smaller for GCK with continuous increased in carbon sink strength. The seasonalities of *NEE, GPP*, and *RE* showed notable differences in carbon sink strength. For GDK, summer was the most productive season but the spring for GCK, except 2009. Both sites experienced a mid-season depression in *NEE* and *GPP* (more pronounced at GCK) resulting from decreased in solar radiation due to intensive rainfall. The mid-season depression was observed every year depending on the intensity and frequency of precipitation. More detail comparison will be presented in terms of light and water use efficiency associated with ecosystem structure and function.

CHARACTERISTICS OF DISSOLVED CARBON CHANGE IN IRRIGATION WATER

Yo Akaike[1], Daisuke Kajihara[1], Keisuke Yoshizawa[1], and Toru Iwata[1]

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

It is necessary to estimate carbon emission from soils for understanding carbon cycle processes in cultivated fields. Since irrigation water is introduced into a typical rice paddy field, one part of emitted carbon content from soils were trapped by water and dissolved in it, and dissolved carbon content outflows from the field at the drainage moment. In this study, we analyzed dissolved carbon content of irrigation water and investigated seasonal efflux of carbon from a paddy field. Experimental site is located reclaimed land in the southern part of Okayama Prefecture, Japan. And rice-barley double cropping cultivation has continued in a similar way every year. Intermittent irrigation water managements, or 4 days flooded and 3 days drained condition, were carried out during almost all the period of rice cultivated term. Irrigation water was sampled from intended field with area of 150m x 50m on every flooding and drainage days, and organic and inorganic carbon concentration was measured with total carbon (TC) analyzer (TOC-V/CSH, Shimadzu). Five sampling points were plotted at even intervals on a diagonal line from flooding channel to drainage channel, and two bottle of water was sampled from every points. The dissolved total carbon content (TC) gradually increased day by day during every flooded periods (Fig.1). TC showed distinct diurnal variations with lower value in the daytime than at night. Such variations were mainly dominated by the change of inorganic carbon content (IC), it is because of photosynthetic activities by aquatic algae in the irrigation water. Dissolved carbon flux (DCF) into irrigation water was estimated from incremental content from each flooded period (Fig.2). DCF showed rapid increase just after the irrigation started and peak value in DCF was shown in mid-summer. DFC gradually decreased in from late-August to early-October.

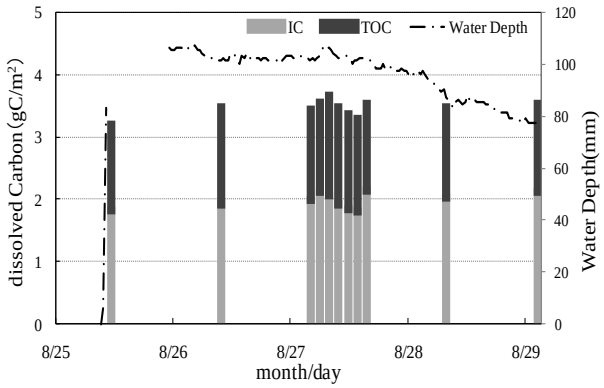


Figure 1. An example of time variations in dissolved total carbon content and water depth between Aug. 25th and 29th in 2010

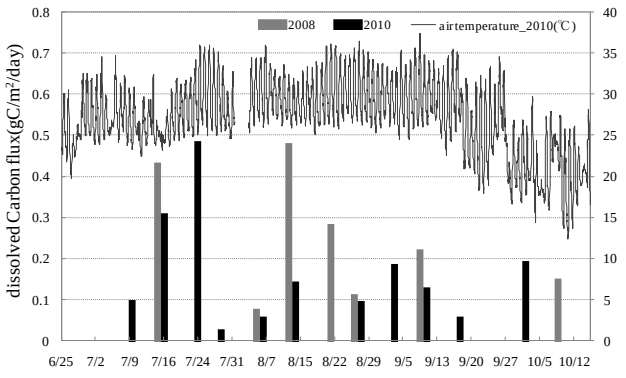


Figure 2. Seasonal change in carbon flux dissolved into irrigation water and air temperature during rice period in 2008 and 2010.

IMPACT OF OPEN BURNING AND BIOMASS DECOMPOSITION ON CARBON BUDGET IN CROPPING FIELD

K.Yoshizawa[1], D.Kajihara[1], S.Shimoda[2], K.Ono[3], T.Takimoto[3], and T. Iwata[1]

[1]*Graduate School of Environmental Science, Okayama University, Okayama, Japan*
[2]*National Agricultural Research Center for Western Region, Fukuyama, Japan*
[3]*National Institute for Agro-Environmental Sciences, Tsukuba, Japan*

Paddy field is one of the most important eco-system in monsoon Asia, and takes a great important role in CO2 uptake. Carbon budget in agricultural field is influenced by some artificial management. After the harvest, residual biomass is burned on the fields, brought out from the fields, or remained and harrowed into the fields. If open burning was conducted in a field, one part of biomass carbon is emitted into atmosphere as CO2, and the other part is harrowed into soils. In this study, quantity of lost carbon according to burning of residual biomass were investigated at the double cropping field in western Japan, in which long-term continuous CO2 flux measurement by the eddy-covariance technique was conducted. Sampling survey of residual biomass was carried out during interval periods twice a year, in early June and early November on 2009 and 2010. One survey is composed three times sampling – whole plant sampling before harvest, residual biomass before burning, and non-burned residuals after burning. Crop yield and quantity of lost carbon were calculated from their differences. Each sample was collected from 7 plots in the field and weighed after drying by the oven with 90degC for 48 hours. Each sample was fractionated into plant region (root, stem, leaf, and panicle) and carbon content ratio for each region was also measured. Table 1 shows carbon content of NPP (net primary production), yield, burning loss, and soil input for 4 cultivated season, 2009-barley, 2009-rice, 2010-barley, and 2010-rice. The ratio of burning loss to NPP for 4 seasons was 17.4%, 24.3%, 35.0%, and 36.5%, respectively. The decomposition rate of large residual biomass of harrowed into soil was estimated during barley season between beginning of December 2009 and early June 2010 and rice season between beginning of July 2010 and middle November 2010. 6 soil samples collected from the field every three weeks, and large residual biomass of the last rice or barley plants more than 1 mm in size was extracted by washout. Then, dried matter weight and carbon content were measured. Figure 1 shows time series of large residual biomass matter in soil for 340 days after harrowing of 2009-rice. Lost carbon content from large biomass during 183 days until next transplanting of rice was estimated as 177 gC m^{-2} and lost carbon content from large biomass during 157 days until next sowing of barley was estimated as 161 gC m^{-2}. Also we examined the relationship between these data, temperature, and soil water contents.

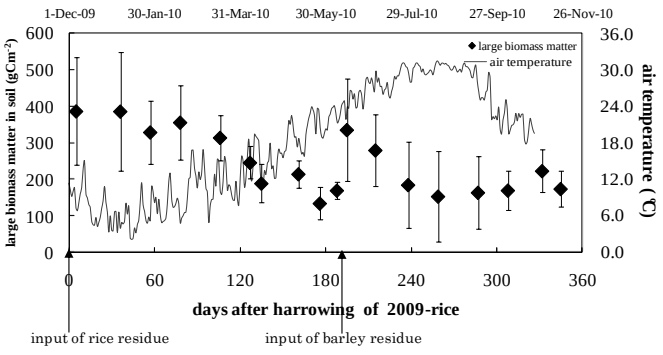


Figure 1. Residual biomass in soil during 340days after harrowing of 2009-rice

Table 1. Distribution of NPP to harvest, burning and input in soil [gCm^{-2}]

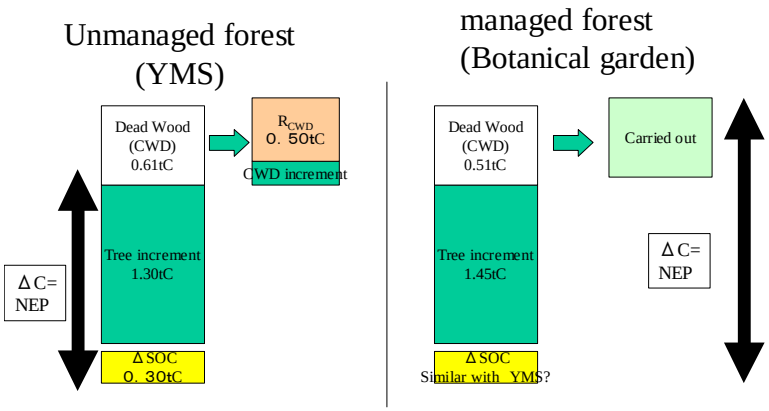
season	NPP	harvest	burning	Input in soil
2009-barley	473(100)	230(48.6)	94(17.4)	161(34.0)
2009-rice	643(100)	260(40.4)	138(24.3)	227(35.3)
2010-barley	540(100)	258(47.8)	199(35.0)	93(17.2)
2010-rice	775(100)	290(37.4)	288(36.5)	202(26.1)

DIVERSITY OF CARBON SEQUESTRATION IN MANAGED AND UNMANAGED BROAD LEAVED FOREST IN JAPAN

Y. Kominami[1], Y. Wada[2], M. Ataka[2], R. Sasaki[2], K. Yoshimura[1], M. Dannoura[2], M. Jomura[3], and C.Uematsu[4]

[1]Kansai Research Center, Forestry and Forest Products Research Institute, Kyoto, Japan.
[2]Faculty of Agriculture, Kyoto University, Japan,
[3]College of Bioresource Sciences, Nihon University, Japan
[4]Botanical Gardens, Faculty of Science, Osaka City University, Japan

Factors of the difference in NEE at various types of the forests are still controversial because various factors are interrelated and conclusion of the research that validates NEE of cross-forests tends to be different (e.g. temperature, vegetation type, nitrogen limit, human management). One of the reason of these differences might be it is difficult to evaluate the factors concerning about biometric factor (e.g. vegetation type, number of trees, forest age) and environmental factors. In this study we tried to evaluate the difference of carbon dynamics between managed and unmanaged broad leaved forest situated on similar environmental conditions. The measurement of NEE and NEP at non-managed broad leaved forest was conducted at Yamashiro experimental forest from 2000 (lat. 34°47'N, long. 135°50'E) located in western Japan. And NEP measurement at managed broad leaved forest was started from 2009 at Botanical Gardens Faculty of Science Osaka City University located about 11 km southwest from YMS site. In each site, forest dominated by deciduous broadleaved tree species such as *Quercus serrata* Thunb. ex Murray and forest age is similar (about 60 years). Forest at Botanical Garden was highly managed and almost dead trees had been carried out. DBH census has been conducted in each site form 1980 (Botanical Garden) and from1994 (YMS) every 5 years. Allometric functions for the estimation of tree biomass in each site were obtained by sampling method in each forest. Until 1950's Botanical Garden was used for a residential and until 1910's YMS site was bare land. Therefore we could assume the initial carbon stock of soil was small enough. And by estimating R_A/R_H ratio of soil respiration and heterotrophic budget using Roth-C model we attempt to estimate carbon accumulation in forest soil (ΔS). Continuous measurements of soil, root and litter leaf respiration of ach forest have been conducted at each forest. Estimated annual mean ΔW in YMS was 1.30 tC ha^{-1} y^{-1} and input of CWD (dead wood) was 0.61 tC ha^{-1} y^{-1}. Estimated annual respiration from total CWD in YMS was 0.50 tC ha^{-1} y^{-1} and estimated annual mean ΔW in Botanical garden was 1.45 tC ha^{-1} y^{-1} and input of CWD (dead wood) was 0.51 tC ha^{-1} y^{-1}. However CWD carbon stock of botanical garden was totally smaller (0.13 tC ha^{-1}) than YMS (9.30 tC ha^{-1}). Therefore respiration from CWD at botanical garden was almost zero. Consequently, forest management (carried out of CWD) could cause increasing of NEP (NEE) at botanical garden and effect of management to total ΔW was 24.0%.



Acknowledgements. This study was supported by KAKENHI no. 21601004and Nippon Life Insurance Foundation.

WATER FLOW THROUGHOUT STEM-BRANCH-LEAF IN CODOMINANT DECIDUOUS AND EVERGREEN TREES

Kenichi Yoshimura[1], Chika Mori[2], Yuji Kominami[1], Kanako Muramatsu[2], and Takafumi Miyama[1]

[1] *Kansai Research Center FFPRI, Kyoto, Japan*
[2] *Nara Women's University, Nara, Japan*

Deciduous secondary forests range in the western part of Japan. Climatically potential vegetation type is evergreen forests and the deciduous forests are being replaced to evergreen forests. One of the reasons for the vegetative succession is species-specific physiological response to the climatic condition. Whole-plant physiology including photosynthesis, respiration and sap flow links to not only the tree-level carbon balance (i.e. tree growth) but also the forest-level carbon balance. Deciduous oak (*Quercus serrata*) dominates Yamashiro Experimental Forest (34°47N', 135°50'E), and above-ground biomass of evergreen trees increases on the other hand (Goto et al. 2004; Funayama 2010). Although mean annual precipitation in this forest is as much as 1449mm, hydraulic stress suffers on the trees especially in summer depending on the interval among rain falls. Sap flow rates of *Q. serrata* decreased with the days after rain fall in summer 2003 using the heat pulse method. Forest-level CO2 uptake decreased with the decrease in the sap flow. Water usage is concerned with not only tree-level carbon uptake but also forest-level carbon uptake even in the wet forest. In this study, to explorer species-specific water use in summer, we compared the pattern in sap flow between deciduous (*Q. serrata*) and evergreen (*Ilex pedunculosa*) with Granier's method in September 2011. Diurnal changes in photosynthetic rates and transpiration rates were measured with LI-6400 in parallel. Contemporary measurements of sap flow, transpiration and photosynthesis can reveal the pattern of whole-plant water use between deciduous and evergreen trees. Sap flow rates, transpiration rates and photosynthetic rates were higher in *Q. serrata* than *I. pedunculosa* (see Figure). Midday transpiration was not depressed compared with sap flow in *Q. serrata*, whereas transpiration was also depressed in *I. pedunculosa* in summer. *Q. serrata* conducted sap flow also in night time, when transpiration stopped. Night-time sap flow rates decreased with vertical position of the stem. This means that sap in the stem is recruited sequentially from the position closed to leaves under the hydraulic stress in *Q. serrata*. *Q. serrata* and *I. pedunculosa* have different pattern in sap flow, and this can affect the water use pattern along the days after the rain fall in summer. Tolerance to dry condition in just several days after rain fall may be necessary for the growth and survival in the warm temperate forest.

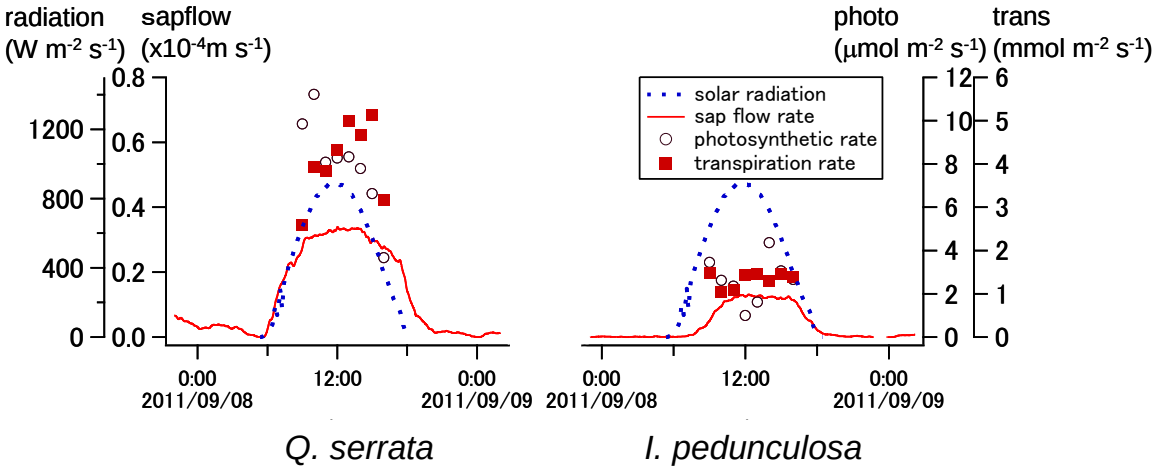


Figure 1. Diurnal change in solar radiation, sap flow, transpiration and photosynthesis in *Q. serrata* and *I. pedunculosa* in warm temperate forest in Japan.

LEAF PHENOLOGY IN A TROPICAL MONSOONAL EVERGREEN FOREST AT SAKAERAT, THAILAND, DETECTED BY FIXED VIEW CAMERA IMAGES - INFLUENCE OF CLIMATE ON THE DELAY OF GREEN-UP IN 2009 -

T. Maeda[1], S. Panuthai[2], T. Artchawakom[3], T. Akitsu[4], and A. Ishida[5]

[1] National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan
[2] Department of National Parks, Wildlife and Plants Conservation, Bangkok, Thailand
[3] Sakaerat Environmental Research Station (SERS), TISTR, Nakhon Ratchasima, Thailand
[4] Graduate School of Life and Environ. Sciences, University of Tsukuba, Tsukuba, Japan
[5] Center for Ecological Research, Kyoto University, Shiga, Japan

By employing the numerical method to objectively detect seasonal variations of phenology of forest canopy by a series of daily fixed view photographs (Maeda and Gamo, 2004, JP Patent 4280823), the leaf phenology of the tropical monsoonal evergreen (dry evergreen) forest around the flux monitoring tower in Sakaerat (SKR), Thailand (14°29'33"N, 101°54'59"E) has been analyzed. The forest canopy is dominated by *Hopea ferrea*, evergreen dipterocarp species. The phenological events could be detected by the seasonal patterns of the normalized intensities (*r*, *g*, and *b*) i.e., the monochromatic intensities of respective channels of RGB, normalized by the panchromatic intensity. The overview of the characteristics of the leaf phenology in this forest, greening-up in the rainy season and its individual variability, found from the analyses on the community and the individual scales were discussed in the previous AsiaFlux workshops. In this presentation, the influence of some climatic parameters on green-up of *Hopea* trees in SKR site during 2006-2009 is discussed. The largest change in the canopy's color by the green-up due to the emergence of new leaves on the surface of the canopy occurs around August, middle of the rainy season in Thailand. In the three years from 2006 to 2008, the greening-up period was during 210-240 DOY and almost same among the years, seeming to be dependent on the daytime length. However, the green-up in 2009 occurred in 270-300 DOY, 2 months later than previous 3 years. The cause of this delay of green-up would be one of the key-factors of the leaf phenology of this forest. The inter-annual comparison of some climatic parameters showed that the soil water content during 200-220 DOY was low at the same level as the dry season by the smaller rainfall in the beginning of the rainy season of 2009, while other factors such as air temperature did not show large difference from other years. Then the greening-up was initiated by the rapid increase of the soil water subsequent to the heavy rain after 240 DOY. The result suggests that the precipitation in the beginning of the rainy season is strongly coupled with the delay of the greening-up.

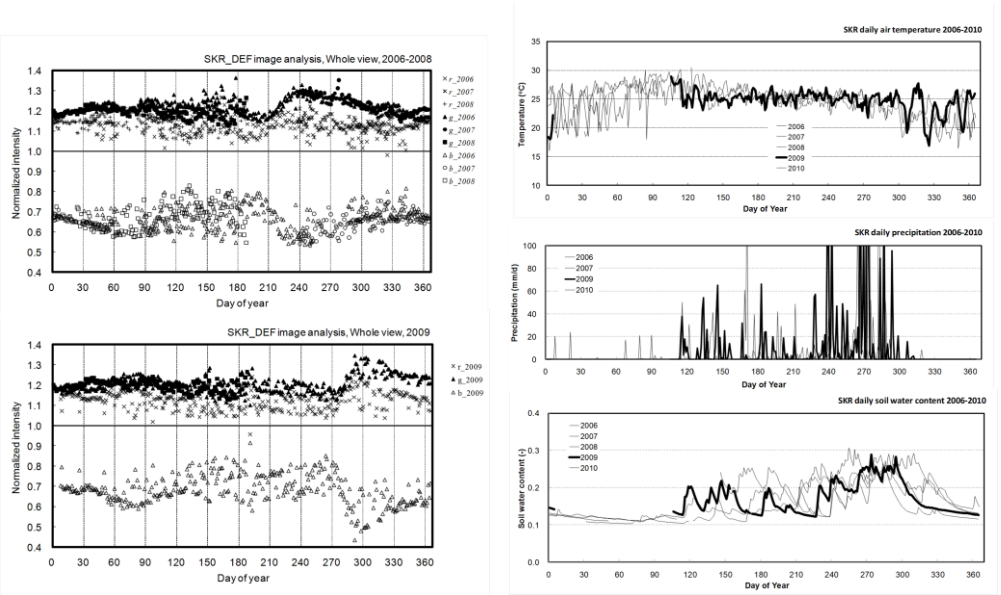


Figure 1. The seasonal variations of the normalized intensities of the forest canopies on the community scale during 2006-2008(upper left) and 2009 (lower left), and the daily air temperature (upper right), precipitation (middle right), and soil water content (lower right) during 2006-2010 at SKR tower. The thick lines indicate the values in 2009.

ECOSYSTEMS CARBON STORAGE AND CARBON SEQUESTRATION POTENTIAL OF SIBERIAN ELM (*ULMUS PUMILA L.*) SPARSE FOREST AND POPLAR PLANTATION (*POPULUS* SP.) ON INNER MONGOLIA PLATEAU, CHINA

Hao Yang[1], Wei Zhao[1], and Shenggong Li[1]

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

Forest is a major carbon sink in terrestrial ecosystem. Studies of carbon storage and carbon sequestration potential have been conducted primarily in temperate and tropical forests. However, few studies have been reported from the semiarid sandy region. In this paper, we assessed the carbon storage and carbon sequestration potential of Siberian elm (*Ulmus pumila L.*) sparse forest and poplar plantation (*Populus* sp.) in Hunshandake Sandland, a semiarid sandy region in Inner Mongolia, China. For our study, we established 24 plots to measure biomass carbon density of trees and herbaceous plants, as well as carbon storage in litter and soil. The plots contained 4 types of Siberian elm sparse forests grew between the 1920s and the 1990s and 4 types of poplar plantation planted between the 1960s and the 2000s. The results showed that, the carbon storage was 35.31, 44.90, 69.44 and 126.10 Mg/hm^2 for the 15-, 33-, 48- and 90-year-old Siberian elm sparse forests and 71.94, 111.20, 108.38 and 274.50 Mg/hm^2 for the 9-, 18-, 30- and 49-year-old poplar plantation ecosystems. Compared to young forests, the carbon sequestration potential is 90.80 Mg/hm^2 for Siberian elm sparse forest in 75 years, and 202.56 Mg/hm^2 for poplar plantation in 40 years. After plantation, carbon storage increased obviously in vegetation, leaf litter, and soil for Siberian elm sparse forest ecosystem, and the carbon sequestration potential is 239.19 Mg/hm^2 in 49 years.

COMPARISON OF COORDINATE ROTATION ON FLUCTUANT TERRAIN

Guo Jianxia[1], and Jiang Ming[2]

[1]Meteorological Observation Centre of CMA, 100081, Beijing, China
[2]Tianjing Meteorological Bureau, 300074, Tianjing, China

Xilinhot National Climate Observatory located in Mongolia grassland with fluctuant terrain. Based on the data of turbulence flux observed by the Eddy Covariance method at Xilinhot National Climate Observatory in 2009, the Double Coordinate Rotation (DR) and Planar Fit (PF) methods are used to revise the effects of the terrain or the instrument tilt on the flux data. The rotation angle and the gradient of local terrain, frictional velocity, CO2 flux, sensible & latent heat flux are investigated. The main results are as following: The revision of DR on the terrain with strong wind speed is better than that with low wind speed. The performance of PF is just well in the main wind flow direction. If averaged period is decreased to 1 hour, the correction trend is similar with the DR correction, but the rotation angle increase by 30% in average. The differences between two methods in the frictional velocity, the CO2 flux, the sensible flux and the latent flux is 1.4%,1.3%,0.8% and 2.8%. The correlation coefficients decrease as the terrain's complex increase. In the 60~120 degree wind direction where the terrain is more complicated, the coefficients is smaller than that in the 210~330 degree wind direction, the average difference is 1.2%.

ENERGY, WATER VAPOR, AND CO_2 EMISSIONS FROM DIFFERENT URBAN LAND USE IN SAKAI CITY

Y. Mitake, M. Ueyama, and K. Hamotani

Osaka Prefecture University, Sakai, Japan

Urban landscapes are hot spots of CO_2 emission to the atmosphere, and its characteristics of energy and CO_2 exchanges are substantially altered by human activities. Owing to its surface heterogeneity, the difference in the land use could influence CO_2 emission rate. In this study, we have conducted a continuous measurement of energy, water vapor, and CO_2 fluxes at a metropolitan area, Sakai (the population: more than 800,000) in Japan in order to identify characteristics of the fluxes in relation to the land uses and human activities.

We have applied an eddy covariance method to measure the sensible heat, latent heat, and CO_2 fluxes at the top of the city office building; the height is 111 m above the street. A sonic anemometer (SAT-550, Kaijo) and an open path gas analyzer (LI-7500, Li-Cor) were installed at the top of the building. The turbulent fluctuations were sampled at 10 Hz. The flux footprint was examined by an analytical footprint model (Kormann and Meixner, 2001) (Figure1). The source area included industrial, commercial and residential areas with a little vegetation. In case source area included the sea surface, flux data were removed.

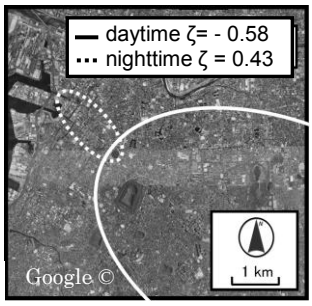


Figure 1. 80% of Source areas for typical days in July 2011.

The large CO_2 emissions were observed with clear diurnal variations (Figure 2). The daytime emission was larger in weekday than in weekend (Figure 2). It was because that human activities varied by a day of the week. CO_2 fluxes from the west and east showed considerably different magnitudes in daytime (Figure 3); emission rate from the west was lager. It probably reflected that west of the city is the center of the metropolitan area, which has many CO_2 source such as traffics and usages of fossil fuels for factories, whereas the dominant land use of the east was residential area. The CO_2 fluxes from east had a second peak on evening especially in winter of 2010 (Figure 3b), which was possibly due to domestic heatings using fossil fuels. The CO_2 emission from the west enlarged in August, September, and December (Figure 4). On the other hand, the flux from the east showed no clear pattern. It was probably because the coolings/heatings and co-generation systems using fossil fuels contributed CO_2 emission. The annual emission for the west and east were 5.4 kg C m^{-2} yr^{-1} and 2.4 kg C m^{-2} yr^{-1} respectively, indicating that the metropolitan area emitted more than 2 times larger CO_2 than the residential area. We conclude that it is important to consider the land use to evaluate CO_2 emission for urban landscapes.

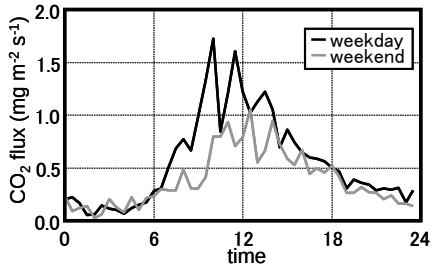


Figure 2. Mean diurnal variations of CO_2 fluxes on weekday and weekend from January to December 2010.

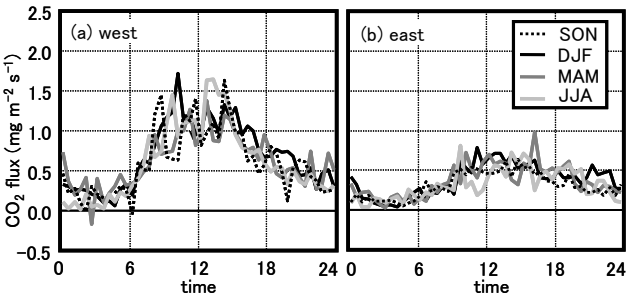


Figure 3. Mean diurnal variations of CO_2 fluxes from west (a) and east (b) of the city from September 2010 to August 2011.

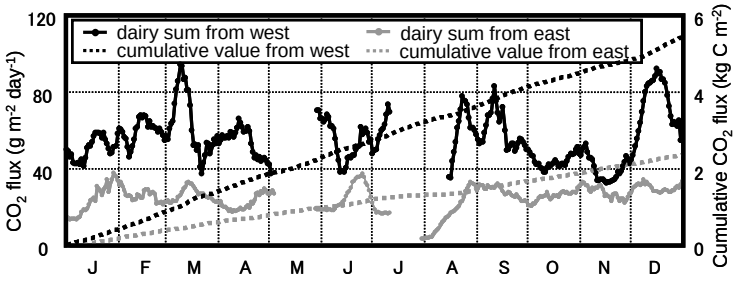


Figure 4. Seasonal variations of CO_2 fluxes from east and west directions.

EFFECTS OF ATMOSPHERIC OZONE AND CO_2 ON ISOPRENE EMISSION FROM *QUERCUS* TREES

A. Tani, and T. Saito

University of Shizuoka, Shizuoka, Japan

Ozone concentration is increasing in East Asia and its effect on crop and tree growth is a great concern. To investigate effects of ozone and CO_2 on isoprene emission from *Quercus serrata*, a 6-month exposure experiment was conducted from May to October 2010 using 12 open-top chambers. Ozone concentration was increased by 40 ppbv by adding ozone gas produced by an ozone generator. Carbon dioxide concentration was raised by adding pure CO_2 from a cylinder and was set 800 ppmv. Isoprene emission rate of *Quercus serrata* was measured with a leaf cuvette method in May, July, September and October. The isoprene emission rate was lower in the high CO_2 treatments than in the ambient CO_2 treatments. It was also lower in the high ozone treatments than in ambient ozone treatments. Isoprene substrate dimethylallyl diphosphate (DMAPP) content in the leaves was also affected by CO_2. However, no combined effects of ozone and CO_2 concentrations on the isoprene emission rate were observed.

WIND TUNNEL EXPERIMENT OF TURBULENCE AT INSIDE AND OUTSIDE OF THE CANOPY WITH LIMITED LENGTH, AND OF FLUX MEASUREMENT ON INCLINED SURFACE

Hiroaki Kondo[1], Akihiro Hori[2], and Katsuhiko Mutou[1]

[1]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan
[2]Meteorological & Environmental Sensing Technology Inc., Tsukuba, Japan

Most of the flux towers measuring energy and CO_2 fluxes are constructed in complex terrain in Asian region. To investigate the problem of fetch and inclined surface, which are often important factors affected by complex terrain, two wind tunnel experiments were conducted. The wind tunnel here used is 3m width, 2m height, and 20m long in the AIST. The first experiment was conducted to investigate flow and turbulence inside and outside of canopy with limited length. A wire mesh that was 2 m long and 0.1m high (=H) was equally spaced perpendicularly to the mean wind flow in the wind tunnel at a 0.1m distance. The length of the area in which the wire mesh was set was 5m (=50H). Mean wind velocity, TKE and Reynolds stress damped at first due to the barrier effect of the wire-mesh canopy. Then, all the three variables took their minimum; however, the locations were closer to the inflow edge for the second moment. Then, they recovered the values to some extent and maintained nearly constant values. The second wind tunnel experiment was flux measurement on the inclined area sources. We set the area sources as shown in Fig.1 and measured wind and C_2H_6, which was used as a tracer, concentration simultaneously. Then flux was calculated with eddy covariance method. The sampling frequency was 1 kHz, and high frequency was cut with low pass filter. The relationship between flux value and coordinate rotation is discussed.

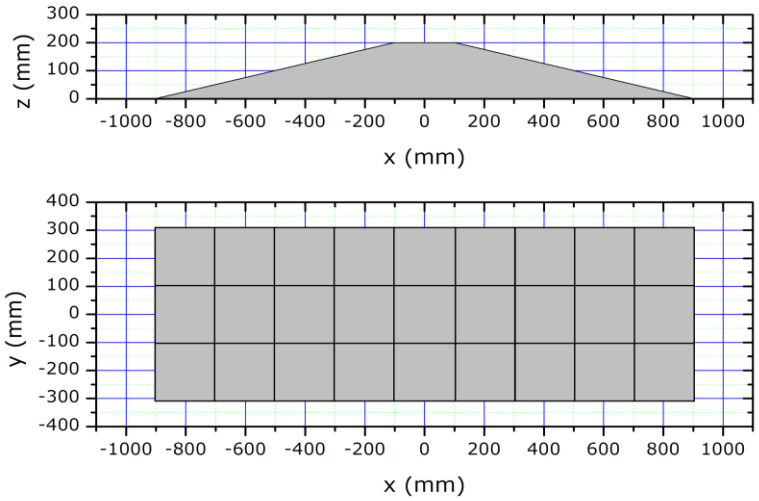


Figure1. Cross section and plane of inclined area source.

AN ANALYSIS OF CANOPY-SCALE RELATIONSHIP BETWEEN PHOTOSYNTHESIS AND STOMATAL CONDUCTANCE IN AN IRRIGATED RICE PADDY

K. Ono[1], M. Mano[1], A. Maruyama[2], T. Kuwagata[1], K. Hayashi[1], and A. Miyata[1]

[1]National Institute for Agro-Environmental Sciences, Tsukuba, Japan
[2]National Agricultural Research Center for Kyushu Okinawa Region, Kumamoto, Japan

Bulk stomatal conductance, g_s, that represents stomatal behavior at canopy scales is generally independent from LAI development and thus more representative of the plant status than the surface conductance in big-leaf approaches. Recently, Maruyama and Kuwagata (2008) assessed diurnal and seasonal variations in g_s of rice canopy and their environmental controls. In their results, g_s showed a typical seasonal variation in accord with the rice growth and relatively symmetric diurnal patterns. In our previous study, temporal variations in g_s were similar at season-long scale but not at diurnal scale: larger in the morning and smaller in the afternoon. These temporal variations in g_s were generally accounted for by those in gross canopy photosynthesis, A_g, derived from eddy covariance measurements (Ono et al, 2011). In this study, we further investigate and quantify the relationship between g_s and A_g under the Ball-Berry-Leuning framework. We calculated g_s by the technique presented by Maruyama and Kuwagata (2008) using the dataset collected at the Mase paddy site, one of the AsiaFlux monitoring stations. Data of three growing seasons between 2004 and 2006 were analyzed. Rice seedlings were transplanted on 2nd May for the three seasons and matured rice was harvested in early to middle September depending on weather conditions. This study focused on the growth periods with LAI > 1 to avoid relatively large errors in g_s calculations. Surface energy imbalance was obvious in the dataset and corrected using the Bowen ratio by eddy covariance every half hour, which enabled us to compare the results with those in Maruyama and Kuwagata (2008). The Ball-Berry parameters and the coefficient of determination, R^2, in the fitting were calculated for each of the morning (–10:00), noon (10:00–14:00), and afternoon (14:00–) data in each growth stages and compared. The Ball-Berry-Leuning slope, m, was found not constant in time. Generally, m was larger in both the vegetative and grain filling stages, and was smaller in the panicle formation and heading stages. A decrease in leaf nitrogen and a slight increase in g_s were also observed in the grain filling stage. Therefore, such large m observed in the two different periods resulted from different mechanism. At a diurnal scale, m tended to be slightly, but significantly small in the afternoon. Shiomono et al. (2010) also found in a rice paddy that m was decreased by 70% in the afternoon applying their leaf-scale measurements to the original Ball-Berry equation and considered the diurnal change in plant water status as one of the reasons. We concluded that the Ball-Berry-Leuning equation represented >70% of the dependence of g_s on A_g in our dataset with a single value of m but still biased at both seasonal and diurnal scales.

CONTINUOUS MEASUREMENT OF CH_4 EMISSION FROM STREAM RIPARIAN ZONE IN WARM TEMPARATE DESIDUOUS FOREST

T. Miyama[1], K. Yoshimura[1], Y. Kominami[1], M. Ataka[2], and M. Okumura[3]

[1] *Kansai Research Center, Forestry and Forest Products Research Institute, Kyoto, Japan*
[2] *Graduate School of Agriculture, Kyoto University, Kyoto, Japan*
[3] *Graduate School of Energy Science, Kyoto University, Kyoto, Japan*

Methane (CH_4) is an important greenhouse gas, contributing about 20% of current radiative forcing, and is a key compound governing the concentration of hydroxyl radicals, a strong regulator of atmospheric chemistry. Regarding the overall circulation of CH_4, upland forests are considered to be net sinks for CH_4 through consumption by methanotrophs in soil. However, some studies have suggested that upland forests may be larger sources of CH_4 than previously believed. In the recent study, we measured CH_4 flux along a mountain stream in the Yamashiro Experimental Forest (YEF) to evaluate spatial and temporal variations in CH_4 emission and found some large CH_4 emission points in the stream and the riparian zone. However, the characteristics and mechanisms of CH_4 emission have not been sufficiently evaluated in detail, mainly due to the difficulty of continuously measuring the CH_4 flux. To evaluate the characteristics, the measurement system should measure some point of soil flux in a riparian zone at the same time. Therefore, we developed a new system for continuously measuring the mulch points of CH_4 flux and conducted preliminarily flux measurements using a Fast Methane Analyzer (FMA, DLT-100, Los Gatos Research, U.S.A.) and 8 channels of automated soil chamber in YEF. The Yamashiro Experimental Forest (YEF) is located in a valley in a mountainous region of western Japan (Kidugawa City, Kyoto Prefecture; 34°47'N, 135°50'E; 220 m a.s.l.). The hill slope between the ridge top and the valley bottom is steep (about 30°), but the slope of the main river channel is gentle (about 5°). The valley is underlain by weathered granite, and the soil is generally thin, immature, and sandy. The annual mean temperature was 15.5°C, and the hourly maximum and minimum temperatures in August and January that year were 34.8°C and 3.9°C, respectively. Annual mean precipitation was 1449 mm; the rainy season was from late June through early July, and typhoons occurred during the summer and fall. The forest consists of more than 50 deciduous (mainly *Quercus serrata Thunb* ex. Murray) and evergreen (mainly *Ilex pedunculosa* Miq) broadleaf species. The forest canopy is closed, and the canopy height is about 12 m on average. In the present study, we measured soil CH_4 flux around the mountain stream in YEF to evaluate spatial and temporal variations using eight automated closed chambers (inner diameter: 20 cm, height: 30 cm). The lid of each chamber was opened and closed automatically by the turning movement of air cylinders once every 2 hours, and it was kept closed during the measurement period of 15 minutes. The movement was controlled by a programmable relay (Omron, ZEN-20C1AR-A-V2, Japan). Four pairs of soil chamber were inserted into the upper soil at: 20 cm from the edge, on the edge, in the middle of the stream, and on the sandbar, respectively. In addition, one side of the soil of the pair of chambers was covered with 40 g of leaf litter. Water level (MWLM-WLM01-KIT, Marutsu, Japan), soil moisture (EC-5, Decagon, USA), water and soil temperatures (T-type thermocouples) were also measured in the chambers. The time-series variations were large, and remarkably high CH_4 emission rates were occasionally observed at the two chambers on the edge of the mountain stream. On the edge, the highest CH_4 emission rate was observed the day after flooding when the temperature was high in summer. The CH_4 emission rate from the soil covered with litter was higher than that without litter. CH_4 emission from the soil covered with litter below the water level was relatively small but stable, possibly due to the covering effect for flora of methane-producing microorganisms under the anaerobic condition of the mountain stream. These results suggest that spatial and time-series variations in CH_4 emission were large, and an unusually high CH_4 emission occurred in the mountain stream the day after flooding in summer. This automated CH_4 flux monitoring system might be useful for accurately estimating the annual total amount of CH_4 emission from streams.

MEASUREMENTS OF METHANE FLUX IN AN EVERGREEN CONIFEROUS FOREST USING A RELAXED EDDY ACCUMULATION AND CHAMBER SYSTEMS

A. Sakabe[1], Y. Kosugi[1], K. Hamotani[2], M. Ueyama[2], K. Takahashi[1], A. Kanazawa[1,3], and M. Itoh[1]

[1]Kyoto University, Kyoto, Japan, [2]Osaka Prefecture University, Sakai, Japan,
[3]Kyoto Prefectural Government, Kyoto, Japan

Forests are generally assumed to be an atmospheric methane (CH_4) sink, representing to about 6% of the global sink (Le Mer and Roger, 2001). However, some forests, which have wide spatio-temporal range in soil water status such as Asian monsoon forests under warm and humid climate, can be CH_4 sources. CH_4 dynamics in whole forest ecosystems are still poorly understood because very few studies have conducted long-term observations of CH_4 flux over forest canopies. In this study, we continuously measured CH_4 fluxes in an evergreen coniferous forest throughout one year from August 2009 using tunable diode laser spectroscopy (TDLS) detection by 1) a relaxed eddy accumulation (REA) method (Hamotani et al., 1996, 2001) to reveal the amplitude and seasonal variations of canopy-scale CH_4 fluxes, and 2) an automated chamber method to reveal the variations of soil CH_4 fluxes and the processes controlling it. The observations were made in an evergreen coniferous forest in Shiga Prefecture, Japan. The site has a warm temperate monsoon climate with a wet summer. Some wetlands were located in riparian zones along streams within the flux footprint area. In the REA method, the sonic anemometer (SAT-550, Kaijo) was mounted on top of the 29-m-tall tower and air was sampled from just below the sonic anemometer to reservoirs according to the direction of vertical wind velocity (w). After accumulating air for 30 minutes, the air in the reservoirs was pulled into a CO_2/H_2O gas analyzer (LI-840, Li-Cor) and a CH_4 analyzer (FMA-200, Los Gatos Research). The REA flux is obtained from the difference in the mean concentrations of the reservoirs. The REA method can take longer time for CH_4 concentration measurements, thus longer signal averaging time and higher precision of the TDLS CH_4 analyzer were achievable. In the chamber method, closed chambers which had automatically opening and closing lids were located at three points of water-unsaturated forest floor, upper, middle and lower parts of hill slope. Soil CO_2 and CH_4 fluxes were measured using the same analyzers with the REA method. We confirmed that the CO_2 fluxes by the EC and REA methods were highly corresponding and the detection limit of the REA method was generally smaller than measured CH_4 fluxes. CH_4 fluxes showed seasonal variations at both canopy and plot scales. Although CH_4 absorption was mostly observed throughout a year in water-unsaturated forest floor, canopy-scale REA CH_4 fluxes switched seasonally between a sink and source of CH_4. It was suggested that the switching of REA CH_4 fluxes was caused by competition between methanogens and methanotrophs, both of which were influenced by soil conditions (e.g., soil temperature and soil moisture), and REA CH_4 fluxes were strongly influenced by the CH_4 fluxes from wetlands within the forest. At hourly to daily timescales, REA CH_4 fluxes were sensitive to rainfall and CH_4 emission increased and/or absorption decreased during and after rainfall (Fig. 1a). We also observed the weakening of CH_4 absorption or switching to emission after rainfall in water-unsaturated forest floor (Fig. 1b).

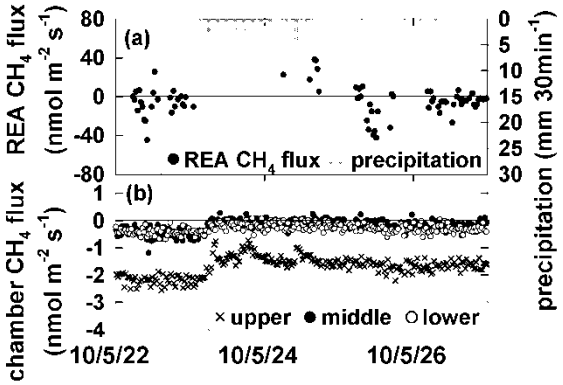


Figure 1. Time series of CH_4 fluxes before and after rainfall for 5 days (22-26 May 2010), (a) canopy CH_4 flux by the REA method and (b) soil CH_4 fluxes by the chamber method.

PARTITIONING OF EVAPOTRANSPIRATION IN A TEMPERATE GRASSLAND THROUGH ISOTOPIC MEASUREMENTS OF H218O

Hu Zhongmin[1], Li Shenggong[1*], Sun Xiaomin[1], Wen Xuefa[1], Lee Xuhui[2], Li Linghao[3], and Yu Guirui[1]

[1]Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China
[2]School of Forestry and Environmental Studies, Yale University, New Haven, CT 06511, U.S.A
[3]Laboratory of Quantitative Vegetation Ecology, Institute of Botany, Chinese Academy of Sciences, Beijing 100093, China

Isotopic labeling is a promising method for partitioning of ecosystem evapotranspiration (ET) into soil and vegetation components. This approach, however, needs continuous measurements of the $^{18}O/^{16}O$ isotope ratios of atmospheric water vapor (δ_v) and of ecosystem evapotranspiration (δ_{ET}) at fine time-resolutions. In this study, a tunable diode laser (TDL) analyzer was deployed for in-situ measurements of δ_v and δ_{ET} in a temperate grassland in Inner Mongolia, China. Based on isotopic signals from the TDL measurements and water in soil, plant laminas and stems, we estimated the isotopic composition of plant transpiration (δ_T) and soil evaporation (δ_E), and partitioned evapotranspiration into plant transpiration and soil evaporation. Our results illustrated that partitioning results from isotopic measurements generally agreed with those estimated from a process-based model. Under the conditions that soil water content was at moderate to low levels, soil evaporation accounted for *ca*. 20% of ET in the afternoon hours (12:30-15:30) during the growing season. On days with very high soil moisture, the isotopic method was likely to underestimate the contribution of soil evaporation, which was possibly due to inappropriate estimate of the isotopic composition of the water at the evaporating point and hence δ_E. An error propagation analysis indicated that δ_{ET} was the most critical term among δ_E, δ_T, and δ_{ET} for accurate partitioning of ET. Special attention should be paid to excluding the low-quality data of δ_{ET} due to the small vertical gradient of vapor concentration. For the purpose of ET partitioning, it was acceptable to use the isotopic composition of plant stems as a substitute of δ_T in the afternoon hours at this site, when the steady state assumption was generally satisfied.

BRANCH RESPIRATION RESEARCH AT THE CHI-LAN MOUNTAIN SITE IN TAIWAN

Pei-Ling Tsai, and Shih-Chieh Chang

Department of Natural Resources and Environmental Studies, National Dong Hwa University, Hualien, Taiwan

Global warming is not only an issue of global concern, but also an issue the world will have to face in the future. Among terrestrial ecosystems, the forest ecosystem is an important sink that has been pointed out to effectively remove atmospheric carbon dioxide. Studies of carbon budgets in forest ecosystems are therefore very important. It has been shown that woody tissue respiration may represent up to 30% of total ecosystem respiration. However, most of the previous studies of woody tissue respiration focused on the stem respiration. The respiration contributed by branches was less addressed, partly due to the difficulty of access to the forest canopy. The Chi-Lan Mountain (CLM) site is a cloud forest ecosystem located in northern Taiwan.Nutrient cycling and carbon budget of this site, including eddy covariance measurement, soil respiration, stem respiration, and carbon storages, have been studied since 2002. To know the carbon flux contributed by branch respiration and its ecophysiological characteristics, we conducted the measurement program in 2011. Here we report the measurement system and a preliminary result. We constructed an automatic chamber system for the continuous measurement of branch respiration at eight positions. The system is composed of eight acrylic cylinder chambers (15 cm in diameter, 20 cm long), one infra-red gas analyzer (LI-820, LI-COR), and one data logger (CR1000, Campbell) for recording data and controlling the system. The open/close of a ventilation window on one side of the chamber is operated by a double acting pneumatic cylinder. We installed the system on four branches of a *Chamaecyparis obtusa* var. *formosana* tree. For each branch two chambers were mounted at the position 15 and 100 cm away from the base of the branch, respectively. The mean diameters of the branches enclosed in the chambers ranged from 3 cm to 5 cm. The CO_2 concentrations in each chamber were measured in sequence, with a measuring time of 3 min for each chamber. To avoid the interference of the air from previous chamber, the first 10 sec data were not included in the calculation of linear increase rate. To assess the temperature dependence of the CO_2 efflux rate, one micro temperature probe was installed 0.5 cm into the branch besides each chamber. The system started its operation in July, 2011. Here we present the preliminary result from the dataset of July 16 to August 27.The CO_2 efflux rates of all chambers showed a typical diurnal variation with higher values observed in daytime. The average value of the eight chambers was 0.44 ìmol m^{-2} s^{-1}during this period, with a range of 0.2to 0.9 ìmol m^{-2} s^{-1}. Compared with the literature data, the CO_2 efflux rate of the *Chamaecyparis obtusa* var. *formosana* branches was of the same magnitude as that of the other tree species. The previous study on stem respiration at the CLM site also suggested, that the woody tissue respiration was not much different between stem and branches of this tree species. Nevertheless, the branches at different canopy positions showed clear spatial patterns. The branch CO_2 efflux rate at higher position was about 49% higher than that of the lower branches. For the same branches, the distal branch sections had about 9% higher CO_2 efflux rates than the proximal ones. Temperature of the branches was a factor influencing the CO_2 efflux rate. The branch CO_2 efflux rate exhibited an exponential growth with branch temperature. To obtain a more detailed picture of branch respiration of the CLM site, the *in situ* measurement and the analysis of the data is being continued. To evaluate the possible effect of internal CO_2 flux driven by sapflow, the installation of sapflow sensors is planned too.

NITROGEN RESPONSE EFFICIENCY OF FOREST ECOSYSTEMS IN EASTERN CHINA AND ITS CONTROLS

Zhan Xiao-yun, and Yu Gui-rui

Institute of Geographic Science and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China

Nitrogen response efficiency (NRE) is an important index to understanding the relationship between the resorption of litter and plant growth, the research of its spatial patterns and controls provide useful information for understanding the relationship between the coupling of carbon and nitrogen properties. Based on continuous observations of carbon fluxes were made at three typical forest sites, which are Dinghu mountain (DHS), Qianyanzhou mountain (QYZ) and Changbaishan mountain (CBS) with eddy covariance systems from 2003 to 2008. NRE was evaluated in term of the ratio of ecosystem gross grimarygroductivity (GPP) to soil available nitrogen (Nsupply). The results showed that there were no significant differences among three sites, but it were in reverse case in differences ecosystems. Average annual NRE was 189.95 kg C·kg-1 N at Dinghu mountain, 299.93 kg C·kg-1 N at Qianyanzhou mountain and 347.07 kg C·kg-1 N at Changbai mountain. It was also found three forest ecosystems had different relationships between GPP and Nsupply. At DHS and QYZ, GPP was significantly correlated to Nsupply, showing a strong non-linear relationship between C gain and soil nitrogen supply. However, the relation was linear for the temperate forests ecosystem. In conclusion, variations in NRE and coupling between C and nitrogen cycles existed, indicating at a certain extent that nitrogen uptake and use of different ecosystem, and also were useful to understanding the plant growth and nitrogen cycles, furthermore, provided theoretical bases for nitrogen management of ecosystem.

MONITORING OF SOIL RESPIRATION IN RICE AND BARLEY DOUBLE CROPPING PADDY-FIELD IN GIMJE, KOREA

Jae-seok Lee[1,*], Eun-hye Lee[1], Joon-seok Yi[1], Young-ju Yu[1], Jung-a Jun[1], Kyo-moon Lee[2], Deog-bae Lee[2], Seul-bi Lee[2], and Sung-hyun Min[2]

[1]Department of Biological sciences, Konkuk University, KOREA
[2]Division of Agro-Climate Change & Ecology, National Academy of Agricultural Science, KOREA

Agricultural systems are sources and sinks for carbon. To quantify the net effect of these systems on atmospheric CO_2 concentration, the amounts of carbon fixed in primary production and that respired by the soil must be known. To monitor soil respiration in rice-barley double cropping paddy-field during the growing season (the rice paddy had been consistently cultivated with double cropping of rice (June ~ October in 2011) and barley (November in 2010~May in 2011), we newly designed "floating" automatic opening/closing chamber (AOCC) system based on closed dynamic method and conducted on field plots measuring with planted to rice. The newly "floating" AOCC system was designed to minimize disturbances to cultivate environmental factors, and also allowed for real-time monitoring of soil respiration. During monitoring (from June to August. in 2011), maximum, minimum, daily mean soil respiration was 228, 3, 58 mg $CO_2\ m^{-2}\ h^{-1}$, respectively. The diurnal variations were not closely related to soil temperatures. At day time (temperature increase), soil respiration was decreased, and at night time (temperature decrease), it was increased. As a result, soil respiration in rice paddy field was basically controlled by ecological condition, greatly influenced by cultivation practices and field management (e.g. stable manure amendment, seeding or transplanting of rice, water management, harvest, treatment of harvest residuals and plowing). We will continuously monitor soil respiration and find characteristics of soil respiration in double cropping rice and barley paddy-field for next 3 years.

Acknowledgements. This research was supported by "CarboEastAsia - A3 Foresight Program" of National Research Foundation of Korea and "Cooperative Research Program for Agricultural Science & Technology Development", Rural Development Administration, Republic of Korea.

SOIL CO2 EFFLUX IN A TEMPERATE DECIDUOUS FOREST: ENVIRONMENTAL DRIVERS SUCH AS SOIL TEMPERATURE AND SOIL WATER CONTENTS

Eun-hye Lee[1*], Young-ju Yu[1], Jung-a Jun[1], Jung-hwa Chun[2], and Jae-seok Lee[1]

[1] Department of Biological Sciences, College of Science, Konkuk University, Seoul, Korea
[2] Division of Forest Ecology, Korea Forest Research Institute, Seoul, Korea

Soil CO_2 efflux is a large component of total respiration in many ecosystems. It is important to understand the environmental controls on soil CO_2 efflux, in order to evaluate potential responses of ecosystems to climate change. This study investigated the relationship between total soil CO_2 efflux and soil temperature, soil moisture on an interannual basis for a plot of temperate deciduous forest in Korea. In order to understand the effects of soil temperature and soil water contents on soil CO_2 efflux, we measured soil CO_2 efflux using a closed dynamic chamber method with an Auto Opening and Closing Chamber system since 2004. Soil CO_2 efflux exhibited pronounced seasonal variations that clearly followed the seasonal changes in soil temperature and soil water contents. Soil CO_2 efflux varied markedly during the study year with high rates in summer and low rates in winter. The mean annual soil CO_2 efflux was 345 mg $CO_2 m^{-2} h^{-1}$, ranging from 10 to 1,210 mg $CO_2 m^{-2} h^{-1}$. Soil CO_2 efflux was highly correlated with temperature during spring and autumn, soil temperature is the main parameter controlling soil CO_2 efflux. On the other hand, soil CO_2 efflux strongly limited by soil water contents (>25%) during the summer, very high soil CO_2 efflux was observed during the summer and immediately after rainfall events. These suggest that random rainfall events may play important role in determining the annual net ecosystem exchange of carbon. The relationship proposed for soil CO_2 efflux with soil temperature and soil water contents is useful for understanding and predicting potential changes in temperate deciduous forest ecosystem in response to forest management and climate change.

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PLANT ROOT AND SHOOT LITTER DECOMPOSITION OF DOMINANT SPECIE *LEYMUS CHINENSIS* IN HULUNBEIER MEADOW STEPPE

Cai Hong Zhang[1,2], Sheng Gong Li[1], Lei Ming Zhang[1], Xing Ren Liu[1,2], and Xiao Ping Xin[3]

[1]Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijng 100101, China
[2]Graduate University of Chinese Academy of Sciences, Beijing 100039, China
[3]Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, China

By using the litterbag method, we explored seasonal dynamics of decomposition of root tissues (rhizome, fibrous root) and shoot litter of *Leymus chinensis*, one of dominant species in a typical meadow steppe in Hulunbeier, Inner Mongolia, China, and the effects of placing positions of the litterbags (on the soil surface and in the 15 cm soil layer) on decomposition. The results indicate that the mass loss rates of root tissues and shoot litter were smaller on the soil surface than that in the 15 cm soil layer, and the mass loss rates of shoot litter and rhizome are significant different at two positions, but that of fibrous root are not. Irrespective of decomposition position, the decomposition rates of three decomposition substrates were shown as: shoot litter> rhizome > fibrous root. Seasonal variation of carbon release showed a similar pattern with the mass loss during the decomposition. But seasonal variation patterns for nitrogen release were significantly different between shoot litter and root tissues (rhizome, fibrous root). Nitrogen release of shoot litter exhibited a pattern of release. And Nitrogen release of rhizome showed a pattern of release in the soil layer, but a pattern of release-increase-release on the soil surface. And Nitrogen release of fibrous root showed a pattern of release in the soil layer, but a pattern of release-increase on the soil surface. Nitrogen content difference in shoot litter (or rhizome, fibrous root) was relatively small at two decomposition positions. Initial chemical compositions and soil moisture played a dominant role in seasonal dynamics of decomposition of rhizome and shoot litter of Leymus chinensis. But Initial chemical compositions were the most main influencing factors, the effects of environmental conditions were small. Our study suggests that future changes of temperature and soil moisture would markedly influence rhizome and shoot decomposition, but not fibrous root decomposition of the meadow steppe in Hulunbeier, Inner Mongolia, China.

EFFECTS OF TREE SPECIES COMPOSITION ON SOIL RESPIRATION IN DECIDUOUS AND EVERGREEN BROAD-LEAVED STANDS

Ryushi Sasaki[1], Masako Dannoura[1], Chiyomi Uematsu[2], and Yuji Kominami[3]

[1]Graduate School of Agriculture, Kyoto University, Kyoto, Japan
[2]Graduate School of Science, Osaka City University, Osaka, Japan
[3]Kansai Research Center, Forestry and Forest Products Research Institute, Kyoto, Japan

Carbon dioxide absorption by forests is a significant factor on global climate change, and soil respiration is one of the largest effluxes in the carbon cycle between forests and the atmosphere. Understanding soil respiration is therefore important in evaluating the carbon sinks of forests. However, it is difficult to determine soil respiration rate because of its large spatial and temporal variations. Composition of tree species is likely to be one of the factors causing these variations. Seasonal differences in litter fall, growth and turnover of fine roots among forests composed of different tree species might cause different seasonal changes in soil respiration. Differences in quality and quantity of litter and fine roots might cause different responses to environmental factors; soil temperature and soil water content. The objective of this study was to reveal the effects of species composition on soil respiration by using four adjacent broad-leaved stands composed of different tree species. We measured soil respiration and CO_2 efflux from litter, and compared the seasonal changes and the response to environmental factors among stands. The study was carried out on two types of deciduous (D1, D2) and two types of evergreen (E1, E2) broad-leaved stands in Botanical Gardens, Osaka City University, Osaka, central Japan. The annual temperature in 2010 was 15.5℃, and annual precipitation was 1604mm. Soil respiration and CO_2 efflux from litter were measured by using closed chambers coupled with IRGAs (GMP343, Vaisala, Finland) and 20cm diameter PVC soil collars. Measurements for soil respiration were conducted periodically from May 2010 on 20 fixed points within a 108 m^2 subplot in each stand. CO_2 efflux from litter was measured by taking out litter inside the collars with meshes inserted between litter and soil surface and by enclosing the litter into a respiration chamber. It was done on four points in each of two stands; D1 and E1.

The seasonal changes of soil respiration in each stand showed a similar pattern (Figure 1). The result suggests that the effects of difference in phenology (e.g. seasonal changes in litter and fine root quantity) by tree species are much smaller than the changes caused by the climatic factor, in broad-leaved temperate forests. While the seasonal pattern was similar among four stands, soil respiration had different relationship to soil temperature and volumetric soil water content between deciduous and evergreen stands. Soil respiration in evergreen stands had higher sensitivity to soil temperature than in deciduous stands. The residuals in the relationship between soil respiration and soil temperature could be explained by volumetric soil water content only in evergreen stands. Soil respiration showed higher value when the soil water content was low in evergreen stands, while no clear relation was observed in deciduous stands. Decomposition of litter was more sensitive to the changes of climate factors than soil respiration. The differences in the sensitivity of soil respiration to climatic factors between deciduous and evergreen broad-leaved stands might be caused by the differences in quality and seasonal changes in quantity of litter and fine roots. Tree species composition is therefore needed to be considered in predicting effects of climate change on soil respiration in broad-leaved forests.

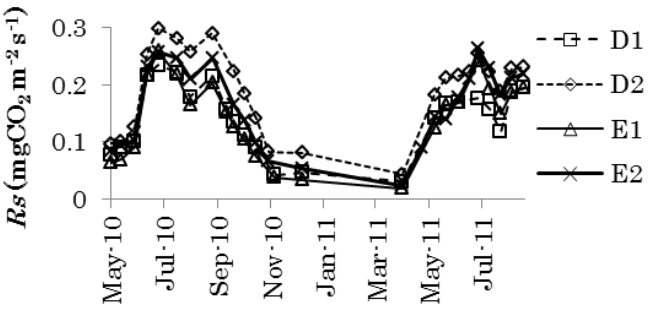

Figure 1. Seasonal changes in soil respiration in four broad-leaved stands.

Acknowledgments. This study was supported by a grant from Nippon Life Insurance Foundation.

THE QUANTIFICATION OF THE METHANE FLUX FROM A PADDY FIELD

Atsuhiro Kunishio, Daisuke Kajihara, Keisuke Yoshizawa, and Toru Iwata

Graduate School of Environmental Science, Okayama University, Okayama, Japan

Paddy fields in monsoonal Asia have a great important role in the global budget of GHGs. In this study, long-term continuous measurements of methane (CH_4) flux were conducted at an intermittently irrigated paddy field in order to assess annual CH_4 budget between air and cultivated field. Besides, we examined effects of air temperature and irrigation water on CH_4 fluxes from paddy fields. Experimental site is located reclaimed land in the southern part of Okayama Prefecture, Japan. And rice-barley double cropping cultivation has continued in a similar way every year. Intermittent irrigation water managements, or 4-days flooded and 3-days drained condition, were carried out during almost all the period of rice cultivated term. CH_4flux was calculated by the aerodynamic gradient technique. Gas inlets were mounted at four levels above the irrigation water and sampled air from each level was continuously sucked and alternately introduced into a FID analyzer (APHA-370, Horiba) every 150 sec. CH_4 concentration was measured and recorded at 1 Hz and vertical gradient of CH_4 concentration was calculated from 30-min averaged values. CO_2 flux observations by the eddy-covariance technique had been also continued for five years between 2006 and 2010. Figure 1 shows CH_4 fluxes during rice period from 2008 to 2010. Under drained conditions, CH_4 emission showed distinct diurnal variations with higher fluxes (10-20 $\mu gCH_4/m^2/s$) in the afternoon than at night. Under flooded conditions, CH_4 emission showed rapid decrease with lower fluxes (0-5 $\mu gCH_4/m^2/s$), and gradual increase day by day. And then, additional enhancement was seen at the beginning of following drained conditions. Such cyclic variations shown from late June, or just after the trans-plantation, until early September. Figure 2 shows relationships between CH_4 flux and air temperature. CH_4 fluxes showed nonlinear increase with air temperature under both irrigation conditions.

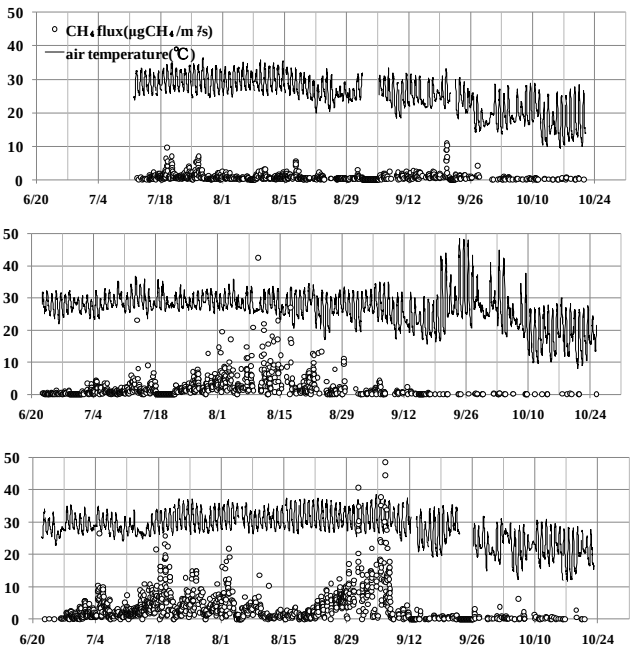

Figure 1. Time variation in methane flux and air temperature in rice periods in 2008(top), 2009(middle) and 2010(bottom).

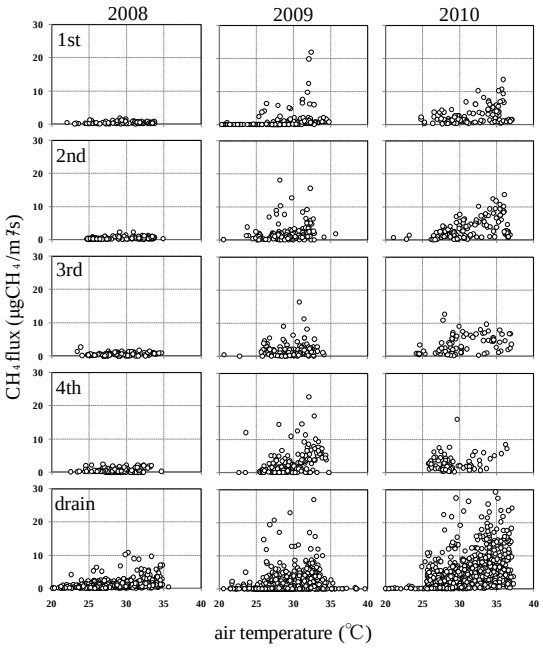

Figure 2. Relationship between methane flux and air temperature on flooded days (upper 4 lows) and drained days (lowest lows) from 2008 to 2010.

SOIL RESPIRATION OF FIVE FOREST TYPES AND THEIR RELATIONS IN SUBTROPICAL CHINA

Yidong Wang[1,2], Huimin Wang[1], Zeqing Ma[1], Wenjiang Zhang[3], Fengting Yang[1], And Mingjie Xu[1]

[1]Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China
[2]Tianjin Key Laboratory of Water Resources and Environment, Tianjin Normal University, Tianjin 300387, China
[3]State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University, Chengdu 610064, China

To improve accuracy of regional carbon budgets, it is required to link forest type to spatiotemporal patterns of soil respiration (R_S). In this study, we measured R_S of five subtropical forest types (slash pine, Masson pine, Chinese fir, coniferous and broad-leaved mixed forest and natural secondary forest) in south China from August 2007 to December 2009. Within same forest type, 2–3 experimental plots with different topography were selected to investigate topographic variation in R_S. Within same forest type, R_S of the experimental plots were similar despite obvious difference in soil temperature and moisture induced by topography; whereas, among different forest types, average and annual R_S were significantly different (P<0.05). This suggested that the spatial variation of R_S was forest-dependent but not affected by topography. However, there was no clear evidence on which factor (soil temperature and moisture, soil organic carbon, total nitrogen, C:N ratio, pH, basal area, aboveground biomass, litter fall input and aboveground litter pool) primarily affected the variation of R_S among forest types. Seasonal R_S were controlled by soil temperature and moisture at all forest types (R^2=0.62–0.81, P<0.001). Synchronously measured R_S among forest plots were linearly correlated (R^2=0.75–0.89, P<0.001) (Fig. 1). Relation slops of R_S between slash pine and Masson pine were found to be stable (CV=2.6%). Therefore, to obtain large area R_S, we could extrapolate R_S from one forest type to other ones using their specific relationships.

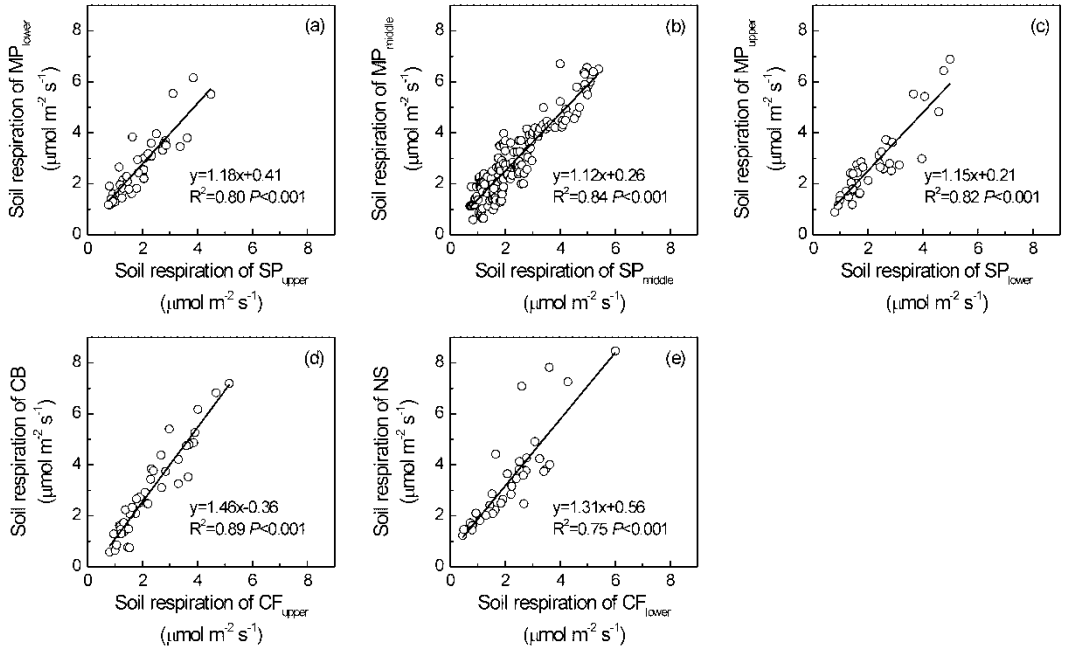

Figure 1. Relationships of soil respiration among forests: SP_{upper} and MP_{lower} (a); SP_{middle} and MP_{middle} (b); SP_{lower} and MP_{upper} (c); CF_{upper} and CB (d); and CF_{lower} and NS (e). NS, CB, MP, SP and CF are natural secondary forest, coniferous and broad-leaved mixed forest, Masson pine, slash pine and Chinese fir, respectively. The subscripts of forest types ($_{upper}$, $_{middle}$ and $_{lower}$) represent slope positions of the experimental plots.

HETEROTROPHIC RESPIRATION IN WARM- AND COOL-TEMPERATE BROAD-LEAVED FORESTS IN JAPAN

M. Jomura[1], M. Ataka[2], H. Yokoyama[1], M. Onuki[1], S. Nakasato[1], K. Kojima[1], C. Morita[1], A. Takahashi[1], Y. Kominami[3], C. Uematsu[4], and S. Sakurai[1]

[1]*College of Bioresource Sciences, Nihon University, Fujisawa, Japan*
[2]*Graduate School of Agriculture, Kyoto University, Kyoto, Japan*
[3]*Kansai Research Center, Forestry & Forest Products Research Institute, Kyoto, Japan*
[4]*Graduate School of Science, Osaka City University, Osaka, Japan*

Heterotrophic respiration (R_H) is one of the major processes releasing carbon to the atmosphere. Various forms of dead organic matter input through tree senescence, litter fall, and fine-root turnover, then are decomposed by soil fauna, bacteria, and fungi. To estimate the net ecosystem production (NEP) of a forest ecosystem, annual R_H on the area of plot basis has to be estimated. However, R_H does not customarily include that of coarse woody debris (R_{CWD}). Moreover, R_H of leaf litter (R_{LL}) is not separated from soil respiration. Understanding of the biological and physical factors that regulate the strength of R_{CWD} and R_{LL} is one of the main topics of the carbon cycle researches. We have measured R_H of dead organic matter of leaf litter and dead wood in some forests consisting of tree species of the same family, Fagaceae, and are located in the different climatic zones. We are now investigating characteristics of CO_2 release through decomposition processes as related to environmental factors and physical and chemical properties of the organic matter. We measured leaf litter respiration (R_{LL}) and coarse woody debris respiration (R_{CWD}) in warm temperate broad-leaved forest (Yamashiro experimental forest, 34°47'N, 135°51'E, Botanical gardens of Osaka University, 34°46'N, 135°41'E and Fujisawa experimental forest, 35°22'N, 139°27'E) and cool temperate broad-leaved forest (Minakami experimental forest, 36°48'N, 139°01'E). We collected samples of leaf litter and coarse woody debris in these sites and measured CO_2 flux of these organic matter using a closed chamber method in monthly scale from 2003 to 2011 (measurement periods were different among samples and the sites). The concentration of CO_2 in the chamber was measured by an infrared gas analyzer (GMP343, Vaisala Inc.). We also measured temperature in the chamber and water content of samples as environmental factors. The details of the measurements were followed Jomura et al. (2007, 2008), Ataka (2011) and Kominami et al. (2008).

R_H had a seasonal variation that showed the largest value in summer season because of high temperature. So we compared the values of R_{CWD} and R_{LL} obtained in the summer season to observe differences in the characteristics among sites. We have modeled R_{CWD} and R_{LL} as a function of environmental factors (temperature and water content) in Yamashiro experimental forest (Jomura et al. 2007 and Ataka 2009). Additionally for the case of CWD, we modeled R_{CWD} as a function of physical characteristics of CWD (diameter and wood density) (Jomura et al. 2007). Then, we estimated R_{CWD} and R_{LL} in the other sites using these models and compared the measured and estimated R_{CWD} and R_{LL}. For the case of CWD, a history, when and how trees were dead and when a standing dead wood were down to the ground, is important information to understand the variation in respiration rate.

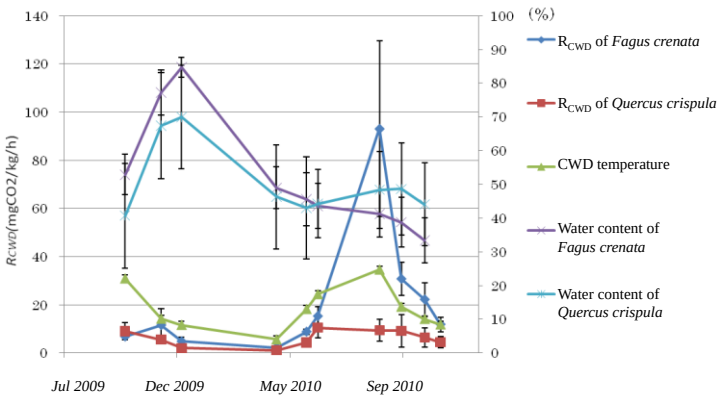

Fig.1 Seasonal changes in RCWD of *Fagus crenata* and *Quercus crispula* in Minakami experimental forest.

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LINKING NATURAL AND SOCIAL FLUXES

T. Machimura[1], T. Matsui[1], and M. Ooba[2]

[1] *Osaka University, Suita, Japan*
[2] *National Institute for Environmental Studies, Tsukuba, Japan*

Aiming to assist sustainable design of circulation oriented societies, a natural and social flux linkage model that calculates carbon, nitrogen and water fluxes among and around ecosystems and a human society was developed (Fig. 1). The ecosystem sub-models were based on well-utilized Biome-BGC and were modified to implement artificial operations of ecosystems, *i.e.* cultivation and harvest. The Forestry-BGC sub-model harvests wood stems in pre-defined intervals or conditions by any harvest intensity, and can calculate regeneration by retaining the transferrable carbon for new growth. The Agro-BGC sub-model contains a compartment of fruits to calculate grain yield in which fruits grow by consuming currently assimilated and reserved carbon according to the development index (DVI) functions considering degree-day and day length. The social sub-model consists of industry, household, houses and buildings, landfill and incineration, and sewage compartments for carbon and nitrogen cycle, and of industry, household, sewage and reservoir for water cycle. Carbon cycle of the social sub-model is linked with the ecosystem sub-models by biomass carbon demand and supply for houses and buildings, wood products, paper and food, and nitrogen flow rate follows the carbon flow rate and materials' C:N ratio.

The house and building, and landfill compartments work as carbon pools, however the other social compartments don't have pools, and the imbalance between social demand and ecosystem supply is compensated by feedstock import and export in the present model version. Nitrogen fertilizer produced by the industry and organic waste from the household can be fed to the soil of Agro-BGC. The reservoir links water cycles of the ecosystems and society by collecting the out flow from Forestry-BGC and by distributing to irrigation, industry and municipal water. The fluxes of sub-models have different unit because the natural fluxes are measured in unit land area whereas those of the industry in per monetary unit and of the household in per capita. In order to link the fluxes, they were multiplied by land area, gross regional production (GRP) or population to know total amount of carbon, nitrogen and water move in a time interval (day). When household population is defined at first, industry size is then determined to satisfy products demand and other social flows can be also determined similarly. A case study of a virtual city having a population of one million and the surrounding forest and cropland in Japan was performed. Required forest and cropland area was examined as well as limiting factors and environmental burdens.

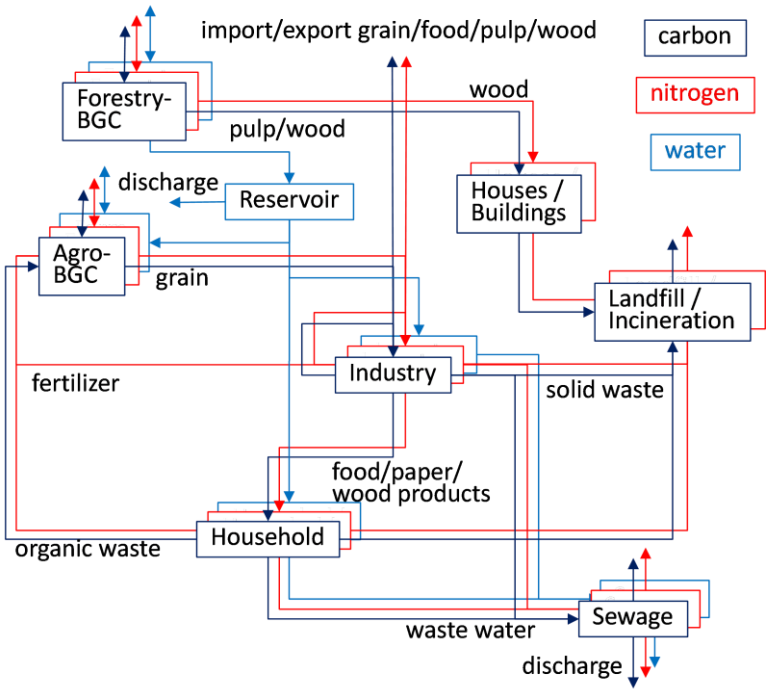

Figure 1. Natural and social flux linkage model.

Acknowledgements. This study was supported by A3 Foresight Program of JSPS and Environment Research & Technology Development Fund of Japanese Ministry of the Environment.

URBAN FLUX AND OTHER MICROMETEOROLOGICAL APPLICATIONS OF THE PICARRO G2311-*f* METHANE, CARBON DIOXIDE, AND WATER VAPOR ANALYZER

Gloria Jacobson[1], Chris Rella[1], Eric Crosson[1], Wade Mcgillis[2], Emma Yates[3] and Olaf Kolle[4]

[1]Picarro Inc., Santa Clara, California, USA.
[2]Lamont Doherty Earth Observatory, Columbia University, New York, USA.
[3]NASA Ames Research Center, Moffett Field, California, USA
[4]Max-Planck-Institute for Biogeochemistry, Jena, Germany

As requirements for flux measurements of greenhouse gases become more demanding, the need for testing new technology in diverse research settings is imperative for full characterization of instrument performance & capability. Picarro has developed a new, high speed, Cavity Ring-Down Spectroscopy (CRDS) based analyzer for measuring carbon dioxide (CO_2), methane (CH_4) and water (H_2O), the G2311-*f*. Concentration measurements are taken at a 30-Hz rate with the result that all three species are measured at 10- Hz with extremely high precision and accuracy. The new flux analyzer has recently been deployed for testing and validation in three different flux research settings: On the largest green roof in New York City with Dr. Wade McGillis, at a desert site in Railroad Valley, Nevada with Dr. Emma Yates, and at the Wetzstein spruce site with Dr. Olaf Kolle from the Max Plank Institute in Germany. Summary data from these deployments is presented to show the instrument's actual performance in highly varied field sites. The new flux instrument has proven capable of a raw 10 Hz precision (one standard deviation) better than 110 parts-per-billion (ppbv) for carbon dioxide, better than 3 ppbv for methane and better than 6ppmv +0.3% of reading for water vapor. Dry mol fractions of CO_2 and CH_4 are reported in real time with corrections for both dilution and spectroscopic effects made automatically. Low level carbon fluxes have been measured even during periods of high latent heat flux. A key additional feature tested is the automatic time-synch and integration of concentration with 3D sonic anemometer data streamed directly to the Picarro via RS232. Multiple measurement modes provide flexibility for measuring fluxes using the eddy-covariance technique, or for use with other techniques that require the high accuracy and precision inherent to the time-based CRDS method such as the gradient flux method, relaxed eddy-covariance, or long-term tall-tower measurements.

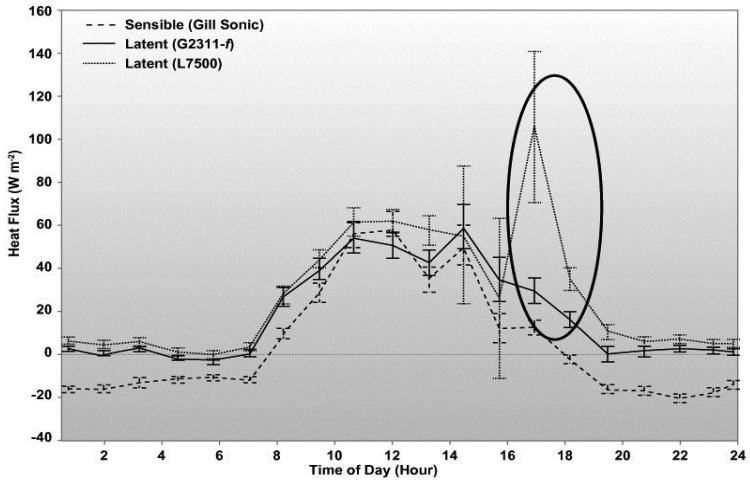

Figure 1. Data from New York City green roof deployment. Data is a five day composite of latent heat fluxes from the Picarro G2311-*f* and LiCOR 7500 as well as sensible heat flux from Gill Sonic anemometer. The instruments track well with the exception of a rain event causing liquid water to condense on the L7500 (circled). Ambient temperatures during the deployment ranged from 92 to 115 degrees F, creating large fluxes during the day.

Acknowledgments. This material is based upon work supported by the Department of Energy SBIR Program under Grant No. DE-FG02-07ER84902 and does not constitute an endorsement by DOE of the views expressed in this presentation.

SUMMER EVAPOTRANSPIRATION BASED ON MULTI-YEAR OBSERVATIONS INCLUDING EXTREME CLIMATIC CONDITIONS OVER A COOL-TEMPERATE EVERGREEN CONIFEROUS FOREST, TAKAYAMA, JAPAN

Saitoh T.M.,[1] I. Tamagawa,[1] H. Muraoka,[1] H. Kondo[2]

[1] *Gifu University, Gifu, Japan*
[2] *National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan*

Evapotranspiration (E) links energy partitioning, carbon exchange, and plant regulation, and also plays a role as a key regulator of ecosystem, atmospheric, hydrological, and biogeochemical processes. Therefore, understanding the response of E to environmental drivers such as air temperature, solar radiation, soil drought, and atmospheric humidity is important, especially in the context of current and future climate change. Long-term continuous flux measurements using the eddy-covariance method provide an opportunity to examine the response of ecosystem processes to climate change. Few studies, however, have focused on the effects of extreme high temperature anomalies on inter-annual variation of E and its environmental responses, especially in the Asian region, even though global warming has been predicted by climate models, particularly in the northern hemisphere. Extremely high temperatures may potentially lead to a change in the response of E to environmental drivers as a result of environmental variation and plant regulation activities. We, therefore, analyzed the inter-annual variation of E by using eddy-covariance data for summer (June–September) over a 5-year period (2006–2010) that included anomalously extreme temperatures over a cool-temperate evergreen coniferous forest (AsiaFlux TKC site) in Japan. The purpose of the study was to (1) clarify inter-annual variation of E in a dry canopy (i.e., no rainfall in the previous 24 h) and its environmental responses and (2) determine the influences of extreme climatic events on the magnitude of inter-annual variation of E and gas exchange properties in a dry canopy. The data included the warmest summer in the past 50 years (2010) and the coolest summer in the past 15 years (2009). We found significant differences between 2009 and 2010 in gas exchange properties such as equilibrium evaporation (E_{eq}) and surface conductance (G_s) in addition to meteorological variables such as air vapor pressure deficit (D_a) and net radiation. The values of E, however, were not significantly different in these two years. Furthermore, the inter-annual variation (coefficient of variance, CV) in E was relatively low (3.5%) as compared with higher values of inter-annual variation in gas exchange properties (4.2–10.0%) and meteorological factors (4.3–18.3%). The relatively steady E can be explained by (1) less effective atmospheric demand (i.e., less sensitive to E_{eq}) because of the low decoupling coefficient (0.07–0.15) at the study site and (2) the negative response of G_s to D_a and a reduced sensitivity of E to high D_a values in relation to plant physiological regulation (i.e., stomatal control). Although E was relatively steady during the observation period at the TKC site, that may not always be the case under future climatic conditions because ongoing global warming has the potential to increase the frequency and magnitude of many extreme climatic events both regionally and globally. At our study site, D_a was relatively higher in July and August and lower in June and September. However, climatic change could cause higher values of D_a in June and September. Further studies on the behavior of E under extreme anomalies in a wider dynamic range are needed to provide the further insight and knowledge of ecosystem responses to climate change.

THE EFFECT OF PATCHY STOMATAL BEHAVIOR ON LEAF- AND CANOPY-SCALE CO_2 FLUX OF A TROPICAL RAINFOREST IN PENINSULAR MALAYSIA, PASOH

Mai Kamakura[1], Yoshiko Kosugi[2], Satoru Takanashi[3], and Elizabeth Philip[4]

[1]Nara Women's University, Nara, Japan
[2]Kyoto University, Kyoto, Japan
[3]Forestry and Forest Products Research Institute, Tsukuba, Japan
[4]Forest Research Institute Malaysia, Kuala Lumpur, Malaysia

The canopy leaves of many tropical trees show midday depression of photosynthesis which is caused by high light occurring with high leaf temperature or water deficit (Ishida et al. Tree Physiol. 1999). In a primary tropical rainforest at Pasoh Forest Reserve in Peninsular Malaysia, the leaf-scale net assimilation rate (A), stomatal conductance (g_s), and the 'apparent' maximum carboxylation rate (V_{cmax}*) in leaves of dipterocarp trees were depressed in the afternoon (Takanashi et al. Tree Physiol. 2006). The apparent maximum carboxylation rate (V_{cmax}*) was estimated from the leaf gas exchange data in the field using one-point method, which is an inverse method based on the Farquhar-von Caemmerer-Berry model. The leaf CO_2 exchange calculations based on the Farquhar-von Caemmerer-Berry model under assumption of uniform stomatal behavior could not explain depressed values of A during midday. Numerical analysis of leaf CO_2 exchange calculated under assumption of patchy stomatal behavior showed that main factor in the inhibition of A during midday was patchy stomatal closure with a bimodal manner (Kosugi et al. Tree Physiol. 2009, Kamakura et al. Tree Physiol. 2011). Direct observation of stomatal aperture distribution in leaves of some canopy tree species consisting tropical dipterocarp forests also demonstrated midday patchy stomatal closure that fits a bimodal pattern.

The objective of this study is to determine whether midday depression of photosynthesis induced by patchy stomatal closure seen in leaves of many canopy trees consisting tropical dipterocarp forests affects canopy photosynthesis. At Pasoh, one of the flux tower sites in Southeast Asia, canopy CO_2 exchange has been measured with eddy covariance method (EC). The core area is covered with a primary lowland mixed dipterocarp forest (tropical evergreen broadleaf forest), consisting of various species of *Shorea* and *Dipterocarpus*. In this site, the diurnal pattern of CO_2 exchange at the canopy-scale also showed a clear restriction of canopy photosynthesis in the afternoon (Kosugi et al. Agric. Forest Meteorol. 2008). Canopy-scale photosynthesis is mainly determined by gas exchange of leaves at the top of the canopy. We investigated the diurnal change of gas exchange parameters at the canopy-scale such as canopy conductance (g_c) and the 'apparent' maximum carboxylation rate of canopy (V_{CMAX}*) using inverse Big-Leaf model analysis of EC fluxes (Kosugi et al. Agric. Forest Meteorol. 2005). Canopy conductance (g_c) and V_{CMAX}* decreased with a reduction of canopy photosynthesis in the afternoon. These results suggest that patchy stomatal behavior affects canopy-scale CO_2 exchange as well as leaf CO_2 exchange.

MEASUREMENT OF AUTOTROPHIC RESPIRATION OF TREE IN PASOH -FROM LEAVES TO ROOTS-

Masako Dannoura[1], Yoshiko Kosugi[1], Satoru Takanashi[2], Naoki Makita[1], Shuhei Kanemitsu[1], Katsunori Tanaka[3], Takehiko Haruta[4], Kaoru Niiyama[5], Abd Rahman Kassim[6], and Abdul Rahim Nik[7]

[1]Graduate School of Agriculture, Kyoto University, Kyoto, Japan
[2]Forestry, Forest Products Research Institute, Tsukuba, Japan
[3]Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan
[4]Faculty of Bioresources, Mie University, Tsu, Mie, Japan
[5]Tohoku Research Center, Forestry, Forest Products Research Institute, Morioka, Japan
[6]Forest Research Institute Malaysia, Kepong, Malaysia
[7]Ministry of Natural Resources and Environment, Putrajaya, Malaysia

Net Primary Production (NPP) of forest is calculated by subtraction of autotrophic respiration (R_a) taken from photosynthesis. R_a is from metabolic process of carbon which plant fixed. Mori et al. (2010) led size dependency of R_a by measuring whole tree's respiration. R_a accounts for 40-70 % of fixed carbon in temperate forest, (Ryan et al., 1995; Saxe et al., 2001), and 70% in tropic forest (Chambers et al., 2004). For accurate estimation of forest carbon cycle, it is needed to combine knowledge of whole ecosystem level and understanding of characteristic of each component. In this research, we measured R_a from each component to scale up to the whole tree. Measurements were conducted in Pasoh Forest Reserve (2°59'N, 102°19'E) in Peninsula Malaysia. This is one of AsiaFlux tower sites, which aimed to compare meteorological measurement with ecological research. The average annual temperature is 25.5°C, and annual precipitation is 1754 mm. Fourteen trees of 0.9 – 29.1 m height were cut in Feb.2010. Sample trees were divided to leaves (n=234), branches (n=157), stems (n=119), coarse roots (n=150) and fine roots (d<2 mm; n=220). Aboveground samples were measured immediately after cutting and belowground parts were just after washing. Cutting sections were covered by silicone to avoid additional wound respiration. CO_2 efflux was measured by closing chamber system connected to IRGA (LI-840, Li-cor, USA). Surface temperature was measured by thermo couple. CO_2 efflux at 25°C was calculated assuming Q_{10}=2.0. Dry weight, diameter, surface area and volume of samples were measured. For leaves and fine roots, we analyzed scanned images for the measurement of surface area. Average respiration rates per sample dry weight (nmol CO_2 g^{-1} s^{-1}; (sd)) from each compartment were 3.42 (1.73) in leaves, 0.85(1.12) in branches, 0.085(0.084) in stems, 0.31(0.29) in coarse roots, 8.16(6.22) in fine roots. Respiration rates per sample weight were higher in ticker leaves, especially well related to Leaf Mass Area (g m^{-2}) (see presentation of Takanashi *et al*.). The leaves, branches, stem which located at higher position had higher respiration rate, but there were some exceptions. Thinner branch and root samples had higher respiration rate per weight. However, root finer than 5 mm in the diameter had high respiration with wide variation. Whole tree's respiration was estimated using the data of tree biomass. Stem respiration was calculated every meter height. Bottom part of stem which has large biomass per unit height has lower respiration than upper part of stem. Thus, it mitigates the height variation within stem. Leaf respiration takes large part in total respiration especially in smaller trees. The composition of respiration from each component changes according with the tree size.

BIOGENIC VOLATILE ORGANIC COMPOUND EMISSIONS FROM THIRTY EIGHT TROPICAL TREE SPECIES IN MALAYSIA

Motonori Okumura[1], Yoshiko Kosugi[2], Satoru Takanashi[3], Mai Kamakura[4], Kazuho Matsumoto[5], Susumu Tohno[1], and Elizabeth Philip[6]

[1]Graduate School of Energy Science, Kyoto University, Kyoto, Japan
[2]Graduate School of Agriculture, Kyoto University, Kyoto, Japan
[3]Forestry and Forest Products Research Institute, Ibaraki, Japan
[4]Kyousei Science Center for Life and Nature, Nara Women's University, Nara, Japan
[5]Faculty of Agriculture, University of the Ryukyus, Okinawa*, Japan*
[6]Forest Research Institute Malaysia, Kuala Lumpur, Malaysia

Biogenic volatile organic compounds (BVOCs) are emitted by many plant species and include terpenoids such as isoprene (C_5H_8), monoterpenes ($C_{10}H_{16}$), sesquiterpenes ($C_{15}H_{24}$) and alcohols. Terpenoids are highly reactive with ozone and hydroxyl radicals as compared with most anthropogenic volatile organic compounds and, therefore, contribute to the formation of ozone and other photochemical oxidants in the lower atmosphere. We conducted measurements of BVOC emissions from leaves of 38 tropical tree species in a nursery at Forest Research Institute Malaysia (FRIM) from 29 January to 3 February 2010. The selected species were located at the middle and upper canopies as well as forest floor levels in Malaysia. The biogenic emission rate, together with the net assimilation rate and photosynthetic photon flux density, was measured using a leaf cuvette (LI6400, Li-cor). BVOC emission from the plant was identified and quantified using gas chromatography-mass spectrometry (GCMS QP2010plus, Shimadzu). The samples underwent thermal desorption by a TD-20 system (Shimadzu), and compound separation was achieved using an SLB-5ms capillary column (30 m × 0.25 mm, ID 1 μm, Supelco). Rate of isoprene emission (I, nmol m^{-2} s^{-1}) from the leaf was calculated according to the following equation

$$I = \left\{ C_{out} \left(\frac{1 - w_{in}}{1 - w_{out}} \right) - C_{in} \right\} v_{in} / LA$$

where C_{in} and C_{out} are the isoprene concentrations (nmol mol^{-1}) in the inflow and outflow samples, respectively, and w_{in} and w_{out}, the water vapor concentrations (mol mol^{-1}) in the inflow and outflow samples, respectively. v_{in} is the flow rate (mol s^{-1}) in the cuvette and LA is the enclosed leaf area (m^2). Screening of BVOC-emitting species showed that 12 tree species were isoprene emitters (Table 1). No isoprene emitter was found in dipterocarp trees.

Table 1. List of tree species measured in this study.

Family	Species		Family	Species
Dipterocarparpaceae	*Shorea singkawang*	*Hopea sublanceolata*	Sapindaceae	*Pometia pinnata*
	S. sumatrana	*H. glaucescens*		*Xerospermum noronhianum*
	S. leprosula	*H. subalata*	Thymelaeaceae	*Gonystylus affinis*
	S. macrantha	*H. auriculata*		*Aquilaria malaccensis*
	S. hemsleyana	*H. bilitonensis*	Lauraceae	*Cinnamomum iners*
	S. lepidota	*Vatica nitens*	Anacardiaceae	*Bouea oppositifolia*
	S. parvifolia	*V. pauciflora*	Meliaceae	*Azadirachta excelsa*
	Dipterocarpus gracilis	*V. flavida*	Moraceae	*Streblus elongatus*
	D. grandiflorus		Lecythidaceae	*Barringtonia fusiformis*
	D. rigidus		Flacourtiaceae	*Flacourtia rukam*
	D. tempehes			
	D. crinitus			
Fabaceae	*Cynometra malaccensis*	*Intsia palembanica*		
	Callerya atropurpurea	*Archidendron bubalinum*		
	Cassia nodosa			
Clusiaceae	*Garcinia hombroniana*	*Mesua ferrea*		
	G. nigrolineata			

VERTICAL PROFILE OF LEAF PHOTOSYNTHETIC CHARACTERISTICS IN A TROPICAL LOWLAND DIPTEROCARP FOREST AT PASOH, PENINSULAR MALAYSIA

Satoru Takanashi[1], Yoshiko Kosugi[2], Takehiko Haruta[3], Masako Danaura[2], Naoki Makita[2], Katsunori Tanaka[4], Kaoru Niiyama[5], Abdul Rahman Kassim[6], and Abdul Rahim Nik[7]

[1]Forestry and Forest Products Research Institute, Tsukuba, Japan
[2]Graduate School of Agriculture, Kyoto University, Kyoto, Japan
[3]Faculty of Bioresources, Mie University, Tsu, Japan
[4]Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan
[5]Tohoku Research Center, Forestry and Forest Products Research Institute, Morioka, Japan
[6]Forest Research Institute Malaysia, Kepong, Malaysia
[7]Ministry of Natural Resources and Environment, Putrajaya, Malaysia

Tropical rainforests are very important for evaluating the role of terrestrial ecosystems in climate change because of their huge biomass and their large gas-exchanges of water vapor or carbon dioxide. Tropical rainforests consist of many sizes of trees. A leaf photosynthetic capacity was mainly controlled by light environment, although trees have own strategies for an efficient photosynthesis conserving their water adapting the environments. To understand H_2O/CO_2 exchange processes of tropical rainforests, we need to know both canopy gas-exchange characteristics (captured by the eddy covariance method) and the distribution of leaf photosynthetic characteristics with their environments. In this study, the electron transport rate for PSII (ETR) and the leaf respiration of tree species in a primary lowland dipterocarp forest were investigated with the tree size, the leaf mass per area (LMA), the height of the leaf. Measurements were conducted at Pasoh Forest Reserve (AsiaFlux site code: PSO, 2°58' N, 102°18' E), Peninsular Malaysia from 31st Jan. to 6th Feb. 2010.We are continuously observing meteorological factors including solar radiation, temperature, humidity, and wind speed and H_2O/CO_2/energy fluxes using the eddy covariance method at an observation tower. More than 800 tree species is present in this study forest. The continuous canopy height is approximately 35 m in height, although some emergent trees exceed 45 m in height. Average plant area index optically measured by a plant canopy analyzer (LAI-2000, Licor, USA) at the tower was about 6.5 m^2 m^{-2}. At 300 m south west from the tower, fourteen trees of 0.9 – 29.1 m height were cut down for the samplings. Leaves were sampled from the cut down tree recoding each height from the ground, and ETR in saturated photosynthetic photon flux density condition of 1000 μmol m^{-2} s^{-1} (ETR_{sat}) was immediately measured using a photosynthesis yield analyzer (Mini-PAM, Waltz, Germany). After measurement of ETR, we measure a leaf dark respiration using three closed dynamic chamber systems, each of which was consisted of a dark chamber, a pump and an infra-red gas analyzer (Li-840, Licor, USA). Additionally, leaves of two emergent tree species which can be sampled at the aluminum canopy walkway at the tower site were measured in the same way. Surface areas of leaves were calculated from the digitalized image taken by a digital scanner before dry weight and leaf thickness were measured. Leaf dark respiration per surface area at 25°C (R_{leaf25}) was calculated assuming Q^{10}=2. Average and standard deviation of ETR_{sat} were 31.6 μmol m^{-2} s^{-1} and 19.0 μmol m^{-2} s^{-1} respectively. Average and standard deviation of R_{leaf25} were 0.37 μmol CO_2 m^{-2} s^{-1} and 0.27μmol CO_2 m^{-2} s^{-1} respectively. Averages of ETR_{sat} and R_{leaf25} grouped by each tree species tend to be high at higher layer and this tendency was found within some tree species. The values of LMA were increased with increase of their height, although scattered in some species. The values of R_{leaf25} were positively related to LMA, and the values of ETR_{sat} were also related to LMA. These results suggest that higher trees adapting their local environment have thicker leaves which are characterized by high photosynthetic capacity and high respiration rate.

RELATIONSHIP BETWEEN LUE AND TOWER-OBSERVED SPECTRAL VEGETATION INDICES IN A TROPICAL RAINFOREST AT PASOH, PENINSULAR MALAYSIA

Tatsuro Nakaji [1], Yoshiko Kosugi [2], Satoru Takanashi [3], Hiroyuki Oguma [4], Abdul Rahim Nik [5]

[1]Hokkaido University, Tomakomai, Japan
[2]Kyoto University, Kyoto, Japan
[3]Forestry and Forest Products Research Institute, Tsukuba, Japan
[4]National Institute for Environmental Studies, Tsukuba, Japan
[5]Ministry of natural Resources and Environment, Putrajaya, Malaysia

The light use efficiency (LUE) is important parameters for the model estimation of productivity of vegetation cover. The LUE is calculated generally as the productivity divided by the absorbed PAR (LUE = GPP/APAR). In the field of forest remote sensing, many researchers has tried to estimate the LUE of forest canopy by using the spectral reflectance, and the Photochemical Reflectance Index (PRI) [(1)] is one of the useful vegetation indices (VIs) for the remote estimation of LUE [(2, 3, 4)]. According to the recent review by Garbulsky *et al.* (2011) [(4)], the positive correlation between the PRI and LUE has been observed in many forest ecosystems. However, the slope of PRI-LUE regression line/curve tends to be varied with varying vegetation types. Grace *et al.* (2007) [(5)] have reported that the slope of the relationship was quite different between the Boreal forests and tropical woodland. The aims of this study are (1) to confirm the sensitivity of PRI and other broadband/hyperspectral VIs in tropical rainforest and (2) to discuss the site-difference of PRI-LUE relationship. We have investigated the seasonal variations of canopy spectral reflectance and CO_2 flux in tropical rainforest at Pasoh Forest Reserve. Eddy CO_2 flux [(3)] and hyperspectral reflectance of forest canopy [(6)] were monitored by using tower-mounted devises since 2002 and 2008, respectively. In this study, we analyzed the field data between Oct 2008 and Dec 2009. Firstly, we compared the variation in the LUE and six VIs (NDVI, EVI, GRVI, PRI, CCI and CI). Although the LUE did not show clear seasonal variation, peaky reduction/increment in LUE (min. 0.007 ~ max 0.020 mol mol^{-1}) was observed at about a monthly interval (data not shown). As for the VIs, similar peaky variation was found in CCI and PRI. The highest correlation coefficient was observed between the LUE and PRI (r = 0.46, p < 0.001). By comparing the LUE-PRI relationship in Pasoh tropical rain forest and other forest types in Siberia, Canada, Japan and Botswana, we found that the slope of regression line tend to be increased with elevating the latitude and/or air temperature (Fig. 1). Although further studies are necessary, these results indicate that the PRI is better index for LUE estimation even in the Pasoh tropical rain forest and the variation in the sensitivity of PRI might be estimated by using meteorological/geological parameter(s).

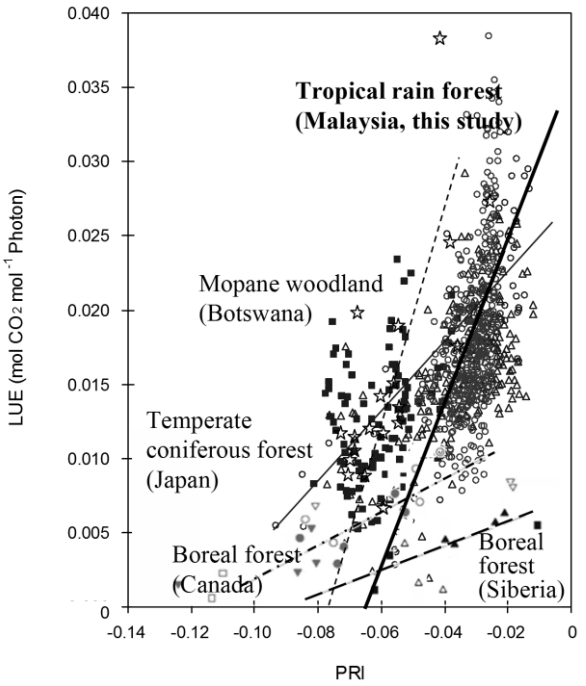

Figure 1. Relationships between photosynthetic LUE and PRI for Boreal forests [(2, 5)], Temperate forest [(3)] and Tropical forest. [(5, this study)]

INTER-SITE COMPARISON OF ECOSYSTEM PHYSIOLOGICAL PARAMETERS OF ASIAN FOREST

K. Takagi[1], R. Hirata[1], M. Ueyama[2], K. Ono[3], R. Ide[4], A. Ogawa[4], T. Hirano[1], N. Saigusa[4], H. Kwon[5], J. Hong[6], Z. Leiming[7], S.-G. Li[7], J. Asanuma[8], M. Gamo[9], S. Han[10], T. Machimura[11], T. Maeda[9], S. Murayama[9], Y. Nakai[12], T. Ohta[13], T. M. Saitoh[14], Y. Takahashi[4], H.-M. Wang[7] and Y.-P. Zhang[7]

[1]Hokkaido University, Sapporo, Japan; [2]Osaka Prefecture University, Sakai, Japan; [3]National Institute for Agro-Environmental Sciences, Tsukuba, Japan; [4]National Institute for Environmental Studies, Tsukuba, Japan; [5]Seoul National University, Seoul, Korea; [6]National Institute for Mathematical Sciences, Daejeon, Korea; [7]IGSNRR, Chinese Academy of Sciences, Beijing, China; [8]University of Tsukuba, Tsukuba, Japan; [9]National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan; [10]Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, China; [11]Osaka University, Suita, Japan; [12]Forestry and Forest Products Research Institute, Tsukuba, Japan; [13]Nagoya University, Nagoya, Japan; [14]Gifu University, Gifu, Japan.

Ecosystem physiological parameters were compared among 21 Asian forests (Table 1) and the relation to ecosystem features and environmental factors were investigated to find universal trend in the parameters. Target physiological parameters were maximum gross primary production at light saturation (A_{max}), the initial slope of the light-response curve (ϕ) and daytime respiration rate (R_d) for photosynthesis, and activation energy (E_0) and the reference respiration rate at 10°C (R_{10}) for respiration. Daily photosynthetic and respiratory parameters were determined by least-squares method using daytime and nighttime net ecosystem exchange within 29 and 39 days moving windows, respectively.

Seasonal maximum of photosynthetic parameters (A_{max}, ϕ, R_d) showed the peaks at temperate forests and obvious increase trend was not observed at the higher temperate regions (Figure 1). Thus the large gross primary production observed in tropical forests could be attributed to the high respiration rate and preferable environmental conditions. Larch forest showed larger A_{max} than those of other forests at temperate regions.

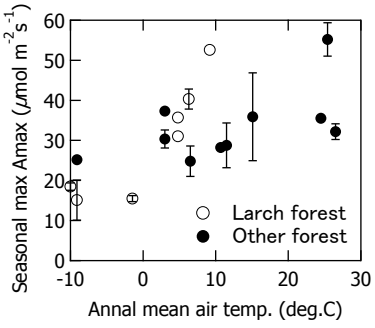

Figure 1 Relationship between seasonal maximum Amax and the annual mean air temperature.

Table 1. Site characteristics

Site	code	Location	Elevation (m)	Dominant species	Year for analysis
Tura, Russia	TUR	64°12' N, 100°27' E	250	*Larix gmelinii*	2004
Nelegel, Russia	NLG	62°19' N, 129°31' E	200	*L gmelinii*	2003-2005
Yakutsuk Larch Forest, Russia	YLF	62°15' N, 129°14' E	220	*Larix gmelinii*	2004-2007
Yakutsuk Pine Forest, Russia	YPF	62°14' N, 129°39' E	220	*Pinus sylvestris*	2004
Southern Khentei Taiga, Mongolia	SKT	48°21' N, 105°39' E	1630	*Larix sibirica*	2004-2005
Laoshan, China	LSH	45°17' N, 127°35' E	370	*Larix gmelinii*	2004
CC-LaG Experiment Site, Japan	TSE	45°03' N, 142°06' E	70	*Larix gmelinii ×L. kaempferi*	2007
Moshiri Birch Forest Site, Japan	MBF	44°20' N, 142°15' E	550	*Betula ermanii*	2004-2005
Moshiri Mixed Forest Site, Japan	MMF	44°19' N, 142°15' E	300	*Betula ermanii, Phellodendron amurense, B. platyphylla var. Japonica, Abies sachalinensis,Picea glehnii*	2005
Tomakomai Flux Research Site, Japan	TMK	42°44' N, 141°31' E	140	*Larix kaempferi*	2001-2003
Forest Ecosystem Open Research Station of Changbai Mountains, China	CBS	42°24' N, 128°05' E	738	*Pinus koraiensis, Tilia amurensis, Acer mono, Quercus mongolia, Fraxinus mandshurica*	2003-2005
KoFlux Gwangneung Supersite, Korea	GDK	37°45' N, 127°09' E	340	*Quercus sp., Carpinus sp.*	2006-2007
Takayama Evergreen Coniferous Forest Site, Japan	TKC	36°08' N, 137°22' E	800	*Cyptomeria japonica, Chamaecyparis obtusa*	2007
Takayama Deciduous Broadleaf Forest Site, Japan	TKY	36°08' N, 137°25' E	1420	*Betula ermanii, Quercus crispula*	1998-2007
Fujihokuroku Flux Observation Site, Japan	FHK	35°26' N, 138°45' E	1100	*Larix kaempferi*	2006
Seto Mixed Forest Site, Japan	SMF	35°15' N, 137°04' E	205	*Quercus serrata, Evodiopanax innovans, Ilex pedunculosa, Pines densiflora*	2003, 2005-2006
Qianyanzhou Experimental Station, China	QYZ	26°44' N, 115°03' E	102	*Pinus massoniana, Pinus elliottii, Cunninghamia lanceolata*	2003-2004
Xishungbanna, China	BNS	21°57' N, 101°12' E	756	*Pometia tomentosa, Terminalia myriocarpa*	2003-2005
Mae Klong, Thailand	MKL	14°35' N, 98°51' E	160	*Shorea siamensis*	2003-2004
Sakaerat, Thailand	SKR	14°29' N, 101°55' E	535	*Hopea ferrea*	2002
Palangkaraya Drained Forest, Indonesia	PDF	2°21' S, 114°02' E	30	*Combretocarpus rotundatus,Cratoxylum arborescens, Buchanania sessifolia, Tetramerista glabra*	2002-2005

FOOTPRINT FOR CARBON DIOXIDE FLUX IN SEVERAL SITES OF FFPRI FLUXNET

K. Yamanoi[1], Y. Mizoguchi[1], Y. Yasuda[2], Y. Ohtani[3], T. Watanabe[4]

[1]Hokkaido Research Center, Forestry and Forest Products Research Institute, Sapporo, Japan
[2]Tohoku Research Center, Forestry and Forest Products Research Institute, Morioka, Japan
[3]Forestry and Forest Products Research Institute, Tsukuba, Japan
[4] Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan

Source area distribution and fetch distance are important factors for flux measurements. In a forest with narrow area, it is important to presume the fetch distance, which influences the measured quantity. If the flux is measured over a heterogeneous forest with different emission rates, the measured quantity reflects the combination of fluxes from different subareas with different weights. The weight of a subarea can be predicted by footprint estimation. In this study,

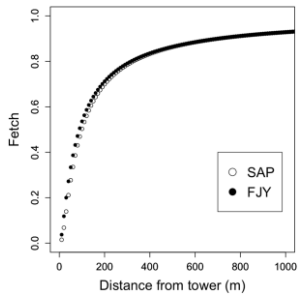

Figure 1. Fetch distances in SAP and FJY sites.

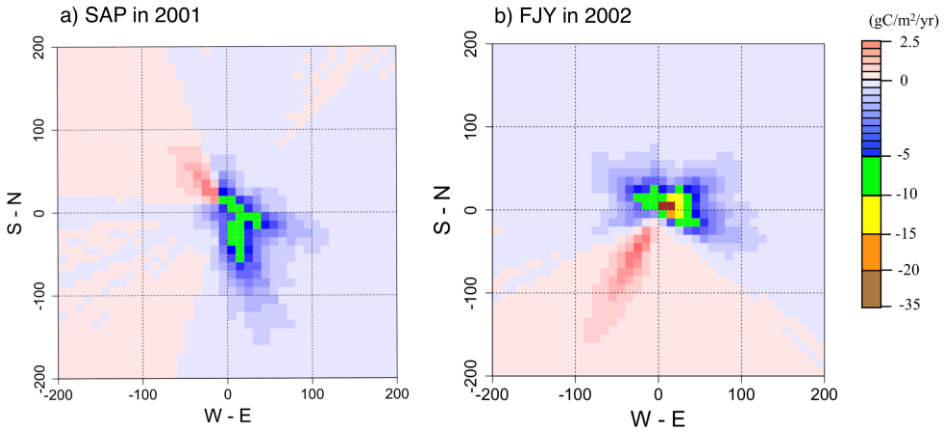

Figure 2. Source area distribution in SAP and FJY sites. Tower is located at center (0,0) of the figure.

the eddy-covariance CO_2 flux measurements were combined with footprint analysis (Hsieh et al., 2000) to deduce CO_2 uptake and to fetch distance in several sites of Forestry and Forest Products Research Institute (FFPRI) FluxNet. Hsieh's model was adapted to four sites—Sapporo (SAP), Fujiyoshida (FJY), Appi (API), and Kawagoe (KWG)—of FFPRI FluxNet. SAP, API, and KWG are covered by deciduous broad-leaf forest, while FJY is covered by evergreen needle forest. All these sites are located on a flat or gentle terrain. Eighty percent flux fetch requirement was calculated on each site. It is the required downwind distance for the measured flux to present 80% of the surface flux. For example, the fetch distances from the observation tower in SAP and FJY were 326 m and 316 m, respectively (Fig.1). SAP is covered with homogeneous deciduous broad-leaf forest within the fetch distance. On the other hand, a part of FJY is covered with roads, parks, and buildings within the fetch distance. The distance to the nearest obstacle is about 250 m in the south. The long fetch distance might influence measurements in FJY. Source area distributions were calculated for the annual CO_2 uptake in SAP and FJY (Fig.2). The strong source areas (CO_2 uptake) were distributed within about 200 m from the towers. As for these distributions, the bias caused by the wind direction was confirmed. During the daytime in growing season, main wind directions of SAP and FJY were south–southeast and east–northeast, respectively. These directions correspond to the uptake area. In winter season, main wind directions of SAP and FJY were northwest and southwest, respectively. The release area was distributed over the direction same as that in the growing season.

UNDERESTIMATED EFFECTS OF LOW TEMPERATURE DURING EARLY GROWING SEASON ON CARBON SEQUESTRATION OF A SUBTROPICAL CONIFEROUS PLANTATION

W.-J. Zhang[1,2], H.-M. Wang[1] and F.-T. Yang[1]

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

[2]State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University, Chengdu 610064, China

The impact of air temperature in early months on the carbon sequestration of a subtropical coniferous plantation was discussed by analyzing the eddy flux observations at Qianyanzhou (QYZ) site located in southern China from 2003 to 2008. This site experienced two cold early growing seasons (with temperature anomalies of 2-5 °C) in 2005 and 2008, and also a severe summer drought in 2003. Results indicated that the low air temperature from January to March was the major factor controlling the inter-annual variations in net carbon uptake at this site, rather than the previously thought summer drought. The accumulative air temperature from January to February showed high correlation (R^2=0.970, $p<0.001$) with the annual net ecosystem production (NEP). This was due to the controls of early-months temperature on the plant phenology developing and the growing season length at this subtropical site. The cold spring greatly shortened the growing season length and therefore reduced the carbon uptake period. The eddy flux observations showed a carbon loss of 4.04 g C m^{-2} per growing-season day at this coniferous forest site. On the other hand, the summer drought also reduced the net carbon uptake strength because the photosynthesis was more sensitive to water deficit stress than the ecosystem respiration. However, the impact of summer drought occurred within a relatively shorter period and the carbon sequestration went back to the normal level once the drought was relieved.

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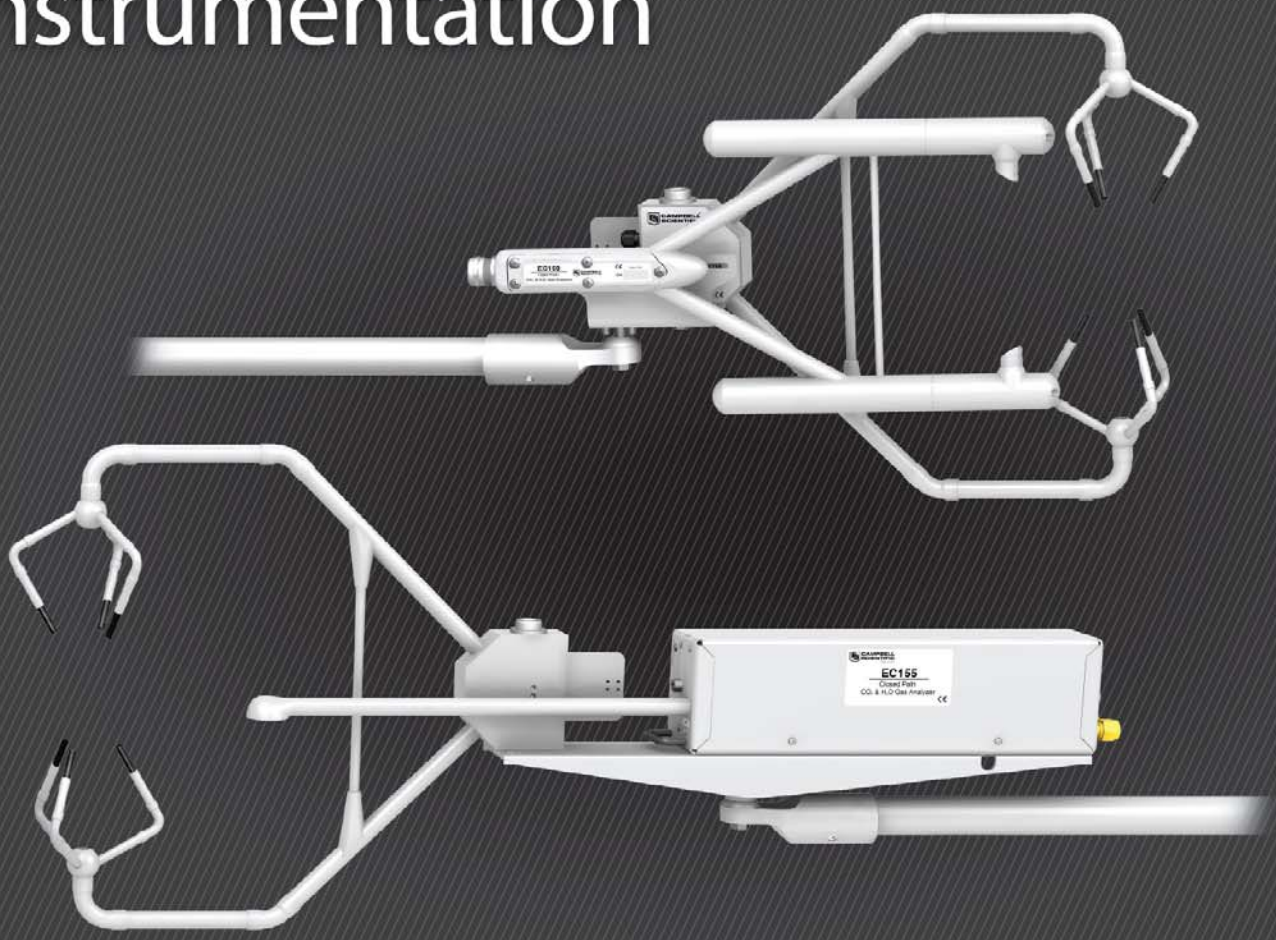

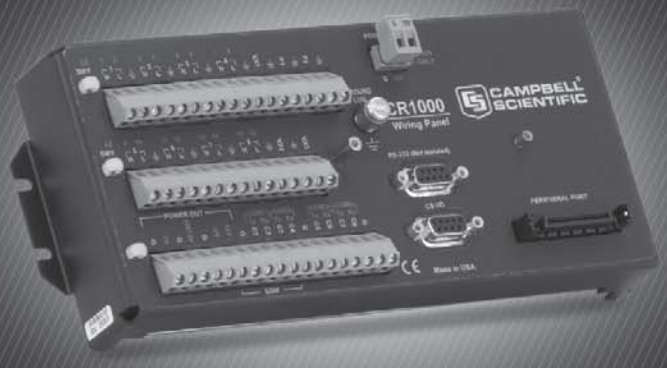

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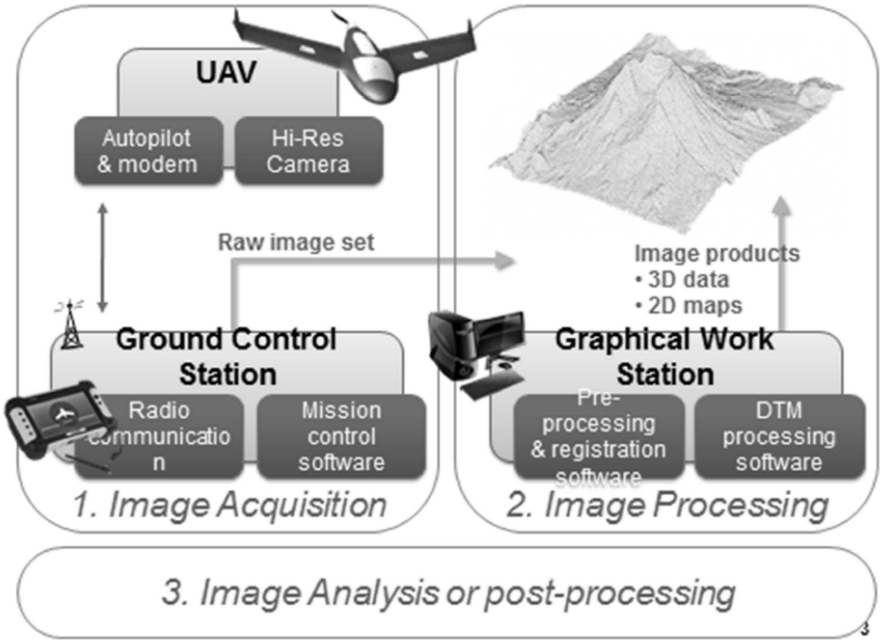

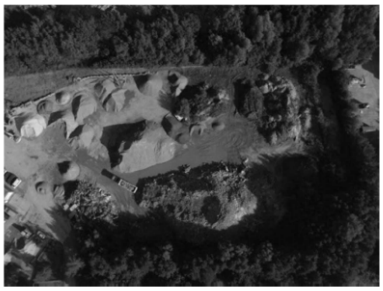

For further enquiries, please contact

Mr Kay Thoan San

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