AsiaFlux2019

-20th Anniversary Workshop-

Sep. 29-Oct.5, 2019

Gifu and Takayama, Japan

Conference Proceedings

AsiaFlux2019
-20th Anniversary Workshop-

September 29-October 1, 2019

Gifu University

1-1 Yanagido, Gifu, Gifu prefecture 501-1193 Japan

October 2-4, 2019

Hida Earth Wisdom Center

900-1 Chishima-machi, Takayama, Gifu 506-0032 Japan

October 5, 2019

Field excursion

City excursion

Contents

Welcome to the 20th anniversary of AsiaFlux

AsiaFlux was established in 1999 as the Asian arm of FLUXNET, the worldwide flux research network, and had its 20th birthday this year. Over the past 20 years, AsiaFlux has hosted 15 workshops, one of which was co-hosted with OzFlux, under the leadership of the past five chairs, through the great efforts of domestic flux networks in Asian countries, and through the administrative support of the National Institute for Environmental Studies, Japan. In addition, AsiaFlux has held training courses 12 times for flux measurement and data analysis and published 39 issues of Newsletter. These successful activities have greatly contributed to the development of flux-related research in Asia and helped young scientists grow.

AsiaFlux will continue to lead flux-related research, contribute to the achievement of Sustainable Development Goals (SDGs) in Asia, and provide an open forum for both field researchers (data providers) and remote-sensing / modeling researchers (data users) to encourage their communication and collaboration. Furthermore, AsiaFlux will advance community collaboration under FLUXNET.

This workshop will celebrate the 20th anniversary of AsiaFlux. The workshop is held in Takayama, Japan, which is known as the flux site with the longest observation record in Asia. Also, Takayama, or Hida Takayama as it is often referred to, is a famous sightseeing spot in Japan, conserving its old town atmosphere. Please enjoy the special workshop and autumn days in Takayama!

Guirui Yu	Takashi Hirano	Kazuhito Ichii
(Chair of AsiaFlux)	(Vice-chair of AsiaFlux)	(Chair of JapanFlux)

Congratulations on 20th anniversary of AsiaFlux

I congratulate AsiaFlux on the occasion of its twentieth anniversary since 1999. The flux study is one of the most important aspects regarding the impacts of global climate change on terrestrial ecosystems. I am delighted that the international workshop titled “AsiaFlux2019 - 20th Anniversary Workshop -” is going to be held from September 29 to October 5, 2019 at Gifu University, Gifu, and Hida Earth Wisdom Center, Takayama, Japan.

The River Basin Research Center (RBRC), Gifu University, was established in 2002. The primary objectives of RBRC is understanding the benefits and risks from nature to the society on a river basin scale. We also focus on putting research outputs to practical use to achieve sustainability of the society. In particular, RBRC has encouraged the long-term observation of carbon dioxide exchange over the forest and ecological research for carbon cycle processes in the forest at the Takayama site, which has the longest flux observation records in Asia. RBRC has also led the so called "Satellite Ecology (SATECO)", an interdisciplinary initiative linking ecology, micrometeorology, modeling and remote sensing to explore the behavior of the ecosystem functions on various temporal and spatial scales.

We have very similar objectives to the AsiaFlux community that focus on the improvement and further understanding of terrestrial ecosystems toward sustainability and quality of life in Asia.

As the director of River Basin Research Center of Gifu University, I sincerely celebrate the 20th anniversary of AsiaFlux. I am convinced that this workshop will be an excellent opportunity for active academic communication for future environmental sustainability in the Asian region.

粟屋善雄

Yoshio Awaya

Director, River Basin Research Center,
Gifu University

Congratulations on the 20th anniversary of the establishment of AsiaFlux!

I was trained as a researcher in the AsiaFlux community and am now working in the Center for Global Environmental Research (CGER), National Institute for Environmental Studies (NIES) of Japan. First, I would like to briefly introduce the long and true bond between AsiaFlux and CGER/NIES.

NIES has been involved in the activities of AsiaFlux since the time of its establishment. The first International Conference of AsiaFlux was held in Hokkaido University in September 2000, and the first AsiaFlux Newsletter was released in March 2002 with devoted contributions of Drs. Gen Inoue and Yasumi Fujinuma working in CGER/NIES, who served as AsiaFlux Secretariat in the early period (Fujiuma et al., 2001; Inoue 2002).

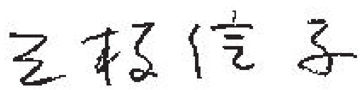
The First Training Course of AsiaFlux in 2006 was supported by NIES as well as the Forestry and Forest Products Research Institute, National Institute of Advanced Industrial Science and Technology, and the National Institute for Agro-Environmental Sciences. Training Courses of AsiaFlux have been helping aspirational members in Asia to mutually learn from each other to enhance science and technology in their own countries and regions.

Now, research fields in AsiaFlux keep expanding from atmospheric science, ecology, hydrology, agriculture and forestry, and biogeochemistry to climate change mitigation/adaptation, biodiversity conservation, food security, and social transformation. Study methods cover not only field observation, remote sensing, and process modelling, but also isotope technology, genetic analysis, deep learning and artificial intelligence, etc. AsiaFlux is connected with over 100 long-term observation sites and active groups in Asia. This is definitely a great asset for fostering ideas and problem consciousness for the next generation of science. Let's create our future by better understanding our present environment based on long-term network observations and by accurately predicting future changes in nature and society of Asia.

References

Fujinuma Y. et al. (Eds.), 2001: Proceedings of International Workshop for Advanced Flux Network and Flux Evaluation. CGER-REPORT, CGER-M-011-2001, ISSN 1341-4356, 191pp. (http://www.cger.nies.go.jp/publications/report/m011/m011_2001.html)

Inoue G. (Ed.), 2002: AsiaFlux Newsletter No.1 (http://asiaflux.net/?page_id=24)



Nobuko Saigusa

Director, Center for Global Environmental Research

National Institute for Environmental Studies

Organizers

- AsiaFlux

- River Basin Research Center, Gifu University

- National Institute for Environmental Studies

Local Organizing Committee Members

- Kazuhito Ichii (Chair) (Chiba University), Japan

- Takashi Hirano (Hokkaido University), Japan

- Hiroyuki Muraoka (Gifu University), Japan

- Yasuyuki Maruya (Gifu University), Japan

- Ichiro Tamagawa (Gifu University), Japan

- Taku M. Saitoh (Gifu University), Japan

- Hideki Kobayashi (Japan Agency for Marine-Earth Sciences and Technology; JAMSTEC), Japan

- Hiroki Iwata (Shinsyu University), Japan

- Tomomichi Kato (Hokkaido University), Japan

- Masahito Ueyama (Osaka Pref. University), Japan

- Ayumi Kotani (Nagoya University), Japan

- Yoshiyuki Takahashi (National Institute for Environmental Studies; NIES), Japan

- Ryuichi Hirata (NIES), Japan

- Hibiki Noda (NIES), Japan

- Munemasa Teramoto (NIES), Japan

- Yukimi Nakata (NIES), Japan

Plenary speakers

Doctor Benjamin Bond-Lamberty

Pacific Northwest National Laboratory, Joint Global Change Research Institute at the University of Maryland, USA

Benjamin Bond-Lamberty (Ph.D., Forest Ecology and Management, University of Wisconsin-Madison, 2003) has over 15 years' experience in ecological modeling, carbon cycle research, and mentoring.

Since 2008 he has been employed by Pacific Northwest National Laboratory, and currently supports four junior scientists while working with many other colleagues in academic and the National Lab system.

He has been repeatedly recognized for his mentorship, reviewing, and high-impact science contributions. His current research interests focus on the numerical modeling of carbon cycling; soils and their resilience in the face of disturbance and climate change; and open, reproducible science.

Dr. Bond-Lamberty is an editor for Ecosystems, Global Biogeochemical Cycles, and Environmental Research Letters.

Professor Dario Papale

University of Tuscia and Euro-Mediterranean Center on Climate Change, Italy

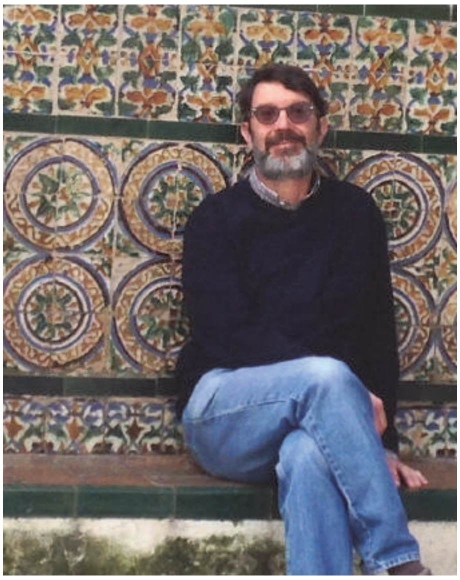
Dario Papale is Associate Professor of Forest Ecology and Remote Sensing in Forestry at the University of Tuscia (Viterbo, Italy) where he also got his Ph.D. in Forest Management and Ecology in 2003 working on artificial neural networks and eddy covariance data. His research interests are in measurements of greenhouse gases exchanges at ecosystem scale and their use in data-model integration and empirical data-oriented models. Since 2004 he has been the responsible scientist for the European Eddy Covariance fluxes databases cluster where eddy covariance data standardization, quality control and uncertainty estimation are developed and applied.

In the last years his main activity and interest has been the development and coherent growth of the global network of eddy covariance sites (FLUXNET). In this context, he was one of the organizers and members of the FLUXNET synthesis activities, where fluxes measured using the eddy covariance technique in more than 250 sites worldwide are standardized, processed and made available to the scientific community. Since then, he continued to work on the development of new methods and techniques to enhance the quality of the eddy covariance measurements, particularly in Europe and the US. He is a member of the AmeriFlux Management Project Team and he has been nominated for the 2013 Director of the Ecosystem Thematic Centre of the Integrated Carbon Observation System (ICOS) in Europe.

He published more than 90 papers in international journals and he is co-editor of a book on the Eddy Covariance technique.

Professor Dennis D. Baldocchi

Department of Environmental Science, Policy & management, University of California, USA



Dennis Baldocchi is a professor of biometeorology at the University of California, Berkeley. He and his research group conduct experimental and theoretical studies on the physical, biological and chemical control of trace gas exchange between vegetation and the atmosphere. Goals of work are to predict fluxes of carbon, water and energy, mechanistically, everywhere, all of the time.

Lines of inquiry have been along understanding how fluxes of mass and energy between ecosystems and the atmosphere vary along a spectrum of time and space scales in accordance with structure, function, weather and climate and management. Methods used include use of the eddy covariance method to measure net fluxes of mass and energy across the atmosphere-ecosystem interface. Data are interpreted and distilled through the lens of the CANVEG family of models, physiological measurements at the leaf scale and flux measurements across the soil-atmosphere interface.

His current work focuses on: 1) the roles of management and ecological restoration on greenhouse gas fluxes of crops and wetlands; 2) the impact of weather, climate trends and variability, physiological stress, and structure and function on the greenhouse gas fluxes of savanna woodlands and annual grasslands; and 3) the upscaling and interpretation of fluxes across climatic and ecological gradients with the AmeriFlux and FLUXNET networks.

Prof. Baldocchi has been principal investigator of FLUXNET since 1997 and is co-investigator of Ameriflux. He is a fellow of the American Geophysical Union, recipient of the American Meteorological Society Award for Outstanding Achievement in Biometeorology and a Clarivate Analytics Highly Cited Scientist over multiple years in Agricultural Science and once in Ecology/Environment.

He served as Editor in Chief of the Journal of Geophysical Research, Biogeoscience, as subject editor of Global Change Biology and on the editorial boards of numerous other journals. He has served on numerous science advisory panels including the Max Planck Institute for Biogeochemistry and the Department of Energy, Biological and Environmental Research Division.

Host and Supporting Agencies

AsiaFlux

GIFU UNIVERSITY
RBRC
RIVER BASIN REASERCH CENTER

NIES

JapanFlux

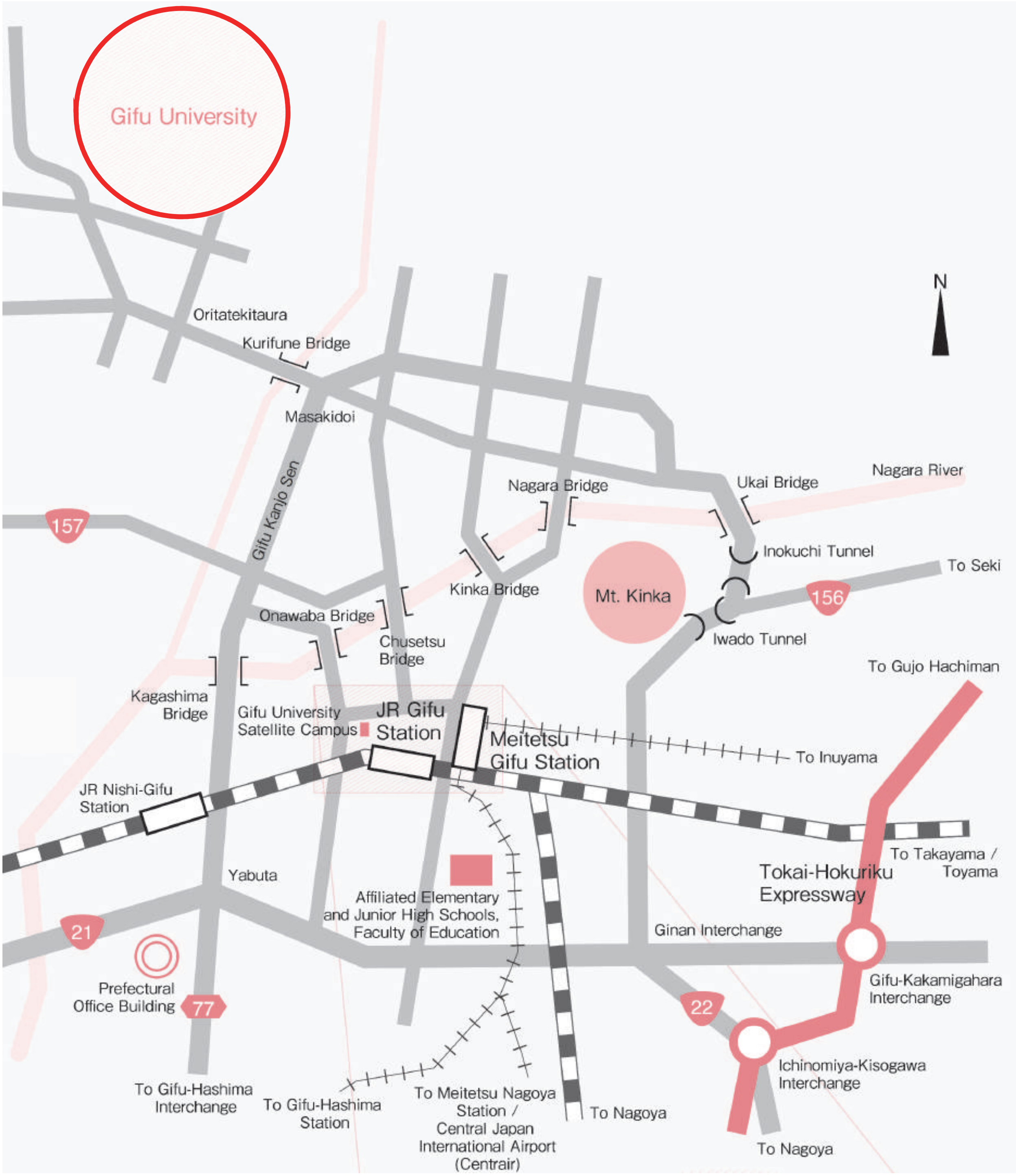
農業気象
日本農業気象学会 The Society of Agricultural Meteorology of Japan

JaLTER

CEReS
Center for Environmental Remote Sensing
Chiba University

一般社団法人
飛騨·高山観光コンベンション協会
HIDA·TAKAYAMA Tourism & Convention Bureau

Local information for the training course: From Gifu Station to Gifu University



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Local information for the training course: From Gifu Station to Gifu University

Please use local bus from Gifu station to Gifu University

Bus Stops

Bus Stops at JR Gifu Eki Kitaguchi (Gifu Station North Exit)

Bus Stop	Line	Route Number	Destination	Time Required
JR Gifu - 9	Gifu University/ University Hospital	C70	Gifu University Hospital	30minutes
JR Gifu - 9	Gifu University/ University Hospital	C71	Gifu University Hospital	25minutes (Seiryu Liner)
JR Gifu - 9	Gifu University/ University Hospital	C72	Gifu University Hospital	25minutes (nonstop)
JR Gifu - 9	Gifu University/ University Hospital	C72	Gifu University	30minutes (nonstop)
JR Gifu - 9	Ginancho (via Nagara Bridge)	N45	Gifu University Hospital	35 minutes

Bus Stops at Meitetsu Gifu Station

Bus Stop	Line	Route Number	Destination	Time Required
Meitetsu Gifu - 5	Gifu University/ University Hospital	C70	Gifu University Hospital	30minutes
Bus Terminal - E	Gifu University/ University Hospital	C72	Gifu University Hospital	25minutes (nonstop)
Bus Terminal - E	Gifu University/ University Hospital	C72	Gifu University	30minutes (nonstop)
Meitetsu Gifu - 4	Ginancho (via Nagara Bridge)	N45	Gifu University Hospital	35minutes

・All buses stop at Gifu University. Buses running via Chusetsu Bridge for Bus Route C.
・No nonstop bus service during school holidays and weekends.
・Seiryu Liner is an articulated bus which has only three stops to Gifu University (capacity: 130 passengers).

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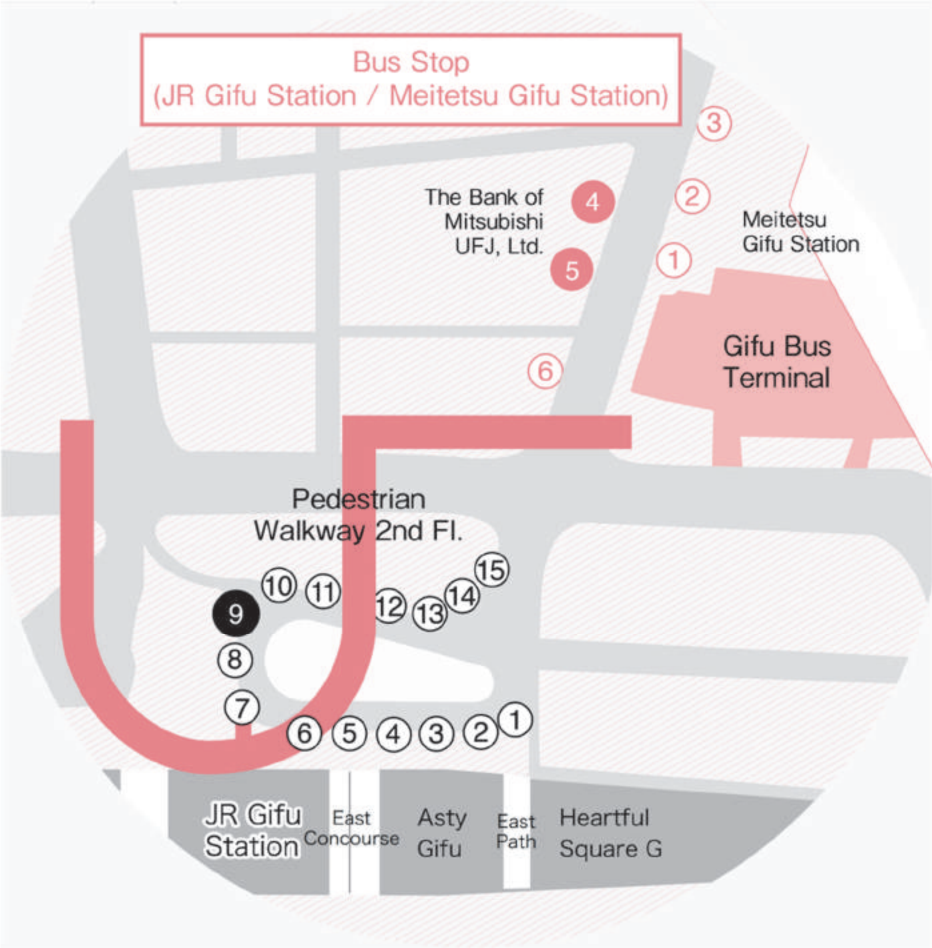
Local information for the training course: From Gifu Station to Gifu University



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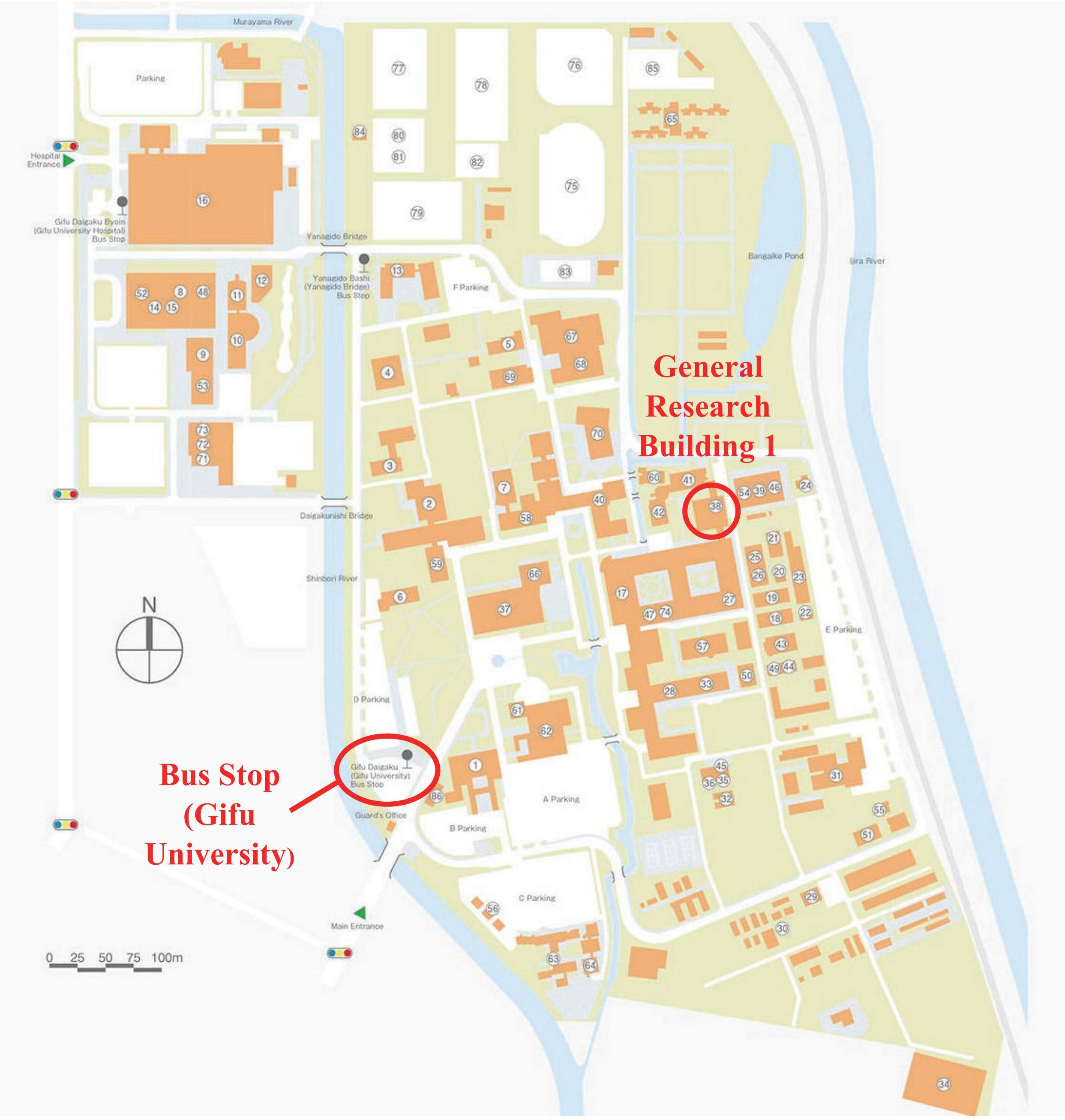
Please get on a bus from bus stop No. 9 (to **Gifu University**) at JR Gifu Station

Venue for the training course:

Room 207, 2nd floor, General Research Building 1, Gifu University



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Gifu University → Takayama city on 1st Oct.
The Local Organizing Committee (LOC) will arrange free transportation service (chartered bus) for workshop participants from Gifu University to Takayama city. (about 2.5 hours) Please bring all your luggage in the morning on 1st Oct.

Lunch:
Day 1 (29 Sept., Sunday): The University cafeteria is closed. Please have lunch somewhere before participating in the course.
Day 2 & Day 3: We recommend that you have lunch in the University cafeteria.

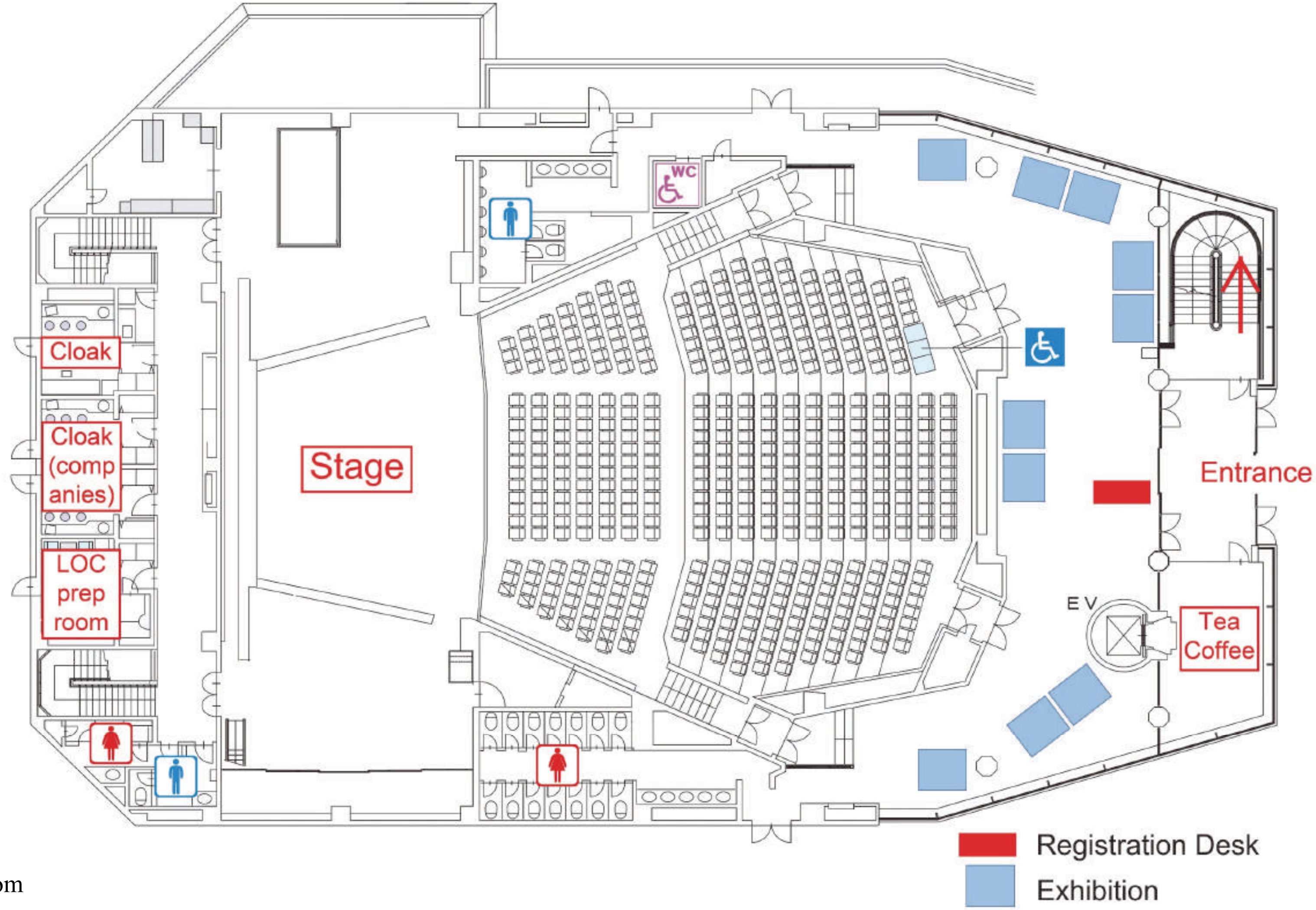
Local information for the conference: Hida Earth Wisdom Center

Retrieved from http://www.hida-center.jp/english/html/guide.html

LOC will prepare a shuttle bus from JR Takayama Station to Hida Earth Wisdom Center for participants. Please refer to the following URL for local information around the venue.

https://www.google.com/maps/d/viewer?mid=15EcpY3LqM-hz5-ZzkizyWSVmc8n8AY5g&usp=sharing

Hida Geijutsudo (Oral session room)



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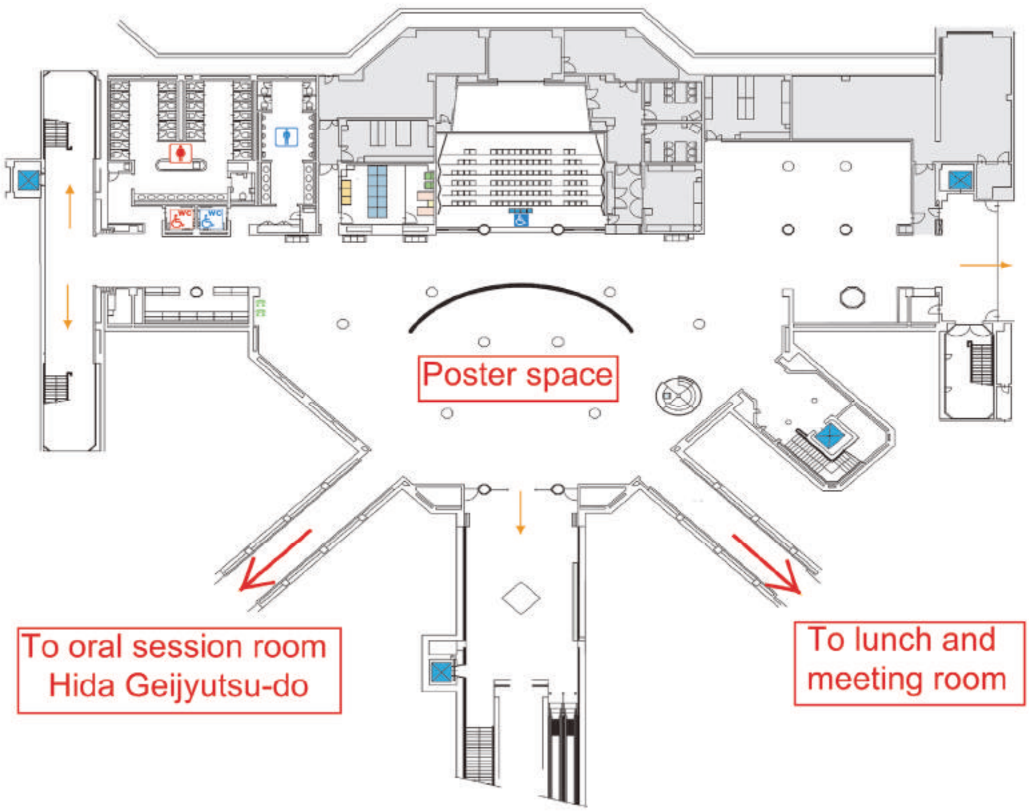
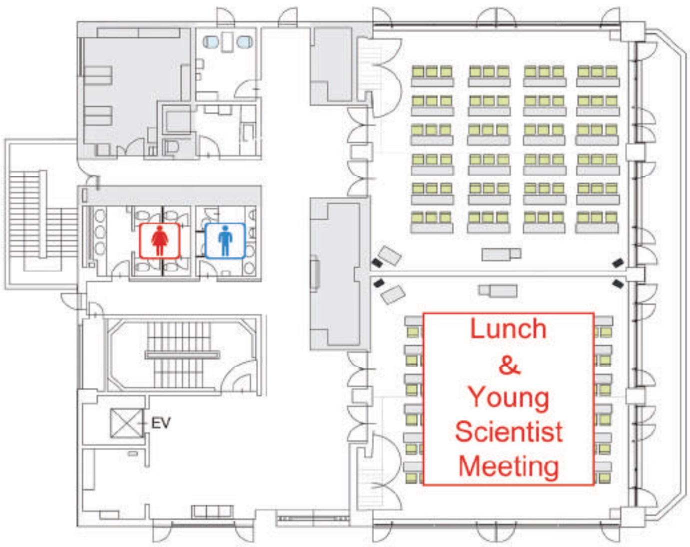
Welcome Plaza (Poster session room)



Lunch and Young Scientist Meeting

Shokuyu-kan 1F: Lunch



Shokuyu-kan 2F Conference room 1:
Lunch and Young Scientist Meeting

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http://www.hida-center.jp/shisetsu/syokuyukan/index.html

Excursions

[1] Field trip to the Takayama flux sites (approx. 8:00-13:00 on October 5, 2019)

■Contents

An approx. 5-hour field trip to two different flux sites (including transit time and toilet break).

■Booking information

Participants need to register in advance using the registration form.

■Tentative schedule on October 5, 2019

8:00: Departure near JR Takayama Station.

8:40-12:20: Field trip to the TKY and TKC sites.

Around 13:00: Arrival back at JR Takayama Station.

■Location of the TKY and TKC sites

The TKY and TKC sites are situated at about 40 and 20 minutes by bus from JR Takayama Station, respectively.

■Climate condition and other information

The maximum air temperature at the sites around noon in early October is expected to be approximately 15 degrees Celsius, but sometimes it is very cold (less than 10 degrees C) even during midday depending on the weather. A warm coat will be useful to protect from cold weather. In case of light rain, the field trip will be conducted. Please prepare hiking shoes and a raincoat for the field trip. In case of heavy rain, the field trip may be canceled.

■Caution

Participants will walk in the forest during the field trip. Please buy an overseas travel accident insurance by yourself and confirm that your insurance covers field activities.

■Detailed site description

The "Takayama site" mainly consists of a cool-temperate deciduous broadleaf forest (TKY) and an evergreen coniferous forest (TKC), which are parts of the AsiaFlux (http://www.asiaflux.net/) and Japan Long-Term Ecological Research (JaLTER, http://www.jalter.org/) networks. The establishment of the Takayama site was initiated for the long-term observation of CO_2 exchange between the atmosphere and the deciduous forest, and ecological research for the carbon cycle processes in the forest, by a number of scientists and students from several research institutes and universities. Efforts have been also made to link ecology, micrometeorology, modeling and *in-situ* remote sensing to explore the ecosystems and surrounding landscape by means of multi-scale investigations. This initiative is called "Satellite Ecology" (SATECO), and is now one of the interdisciplinary initiatives for cross-scale observation of ecosystems.

[2] City excursion to Takayama city (October 5, 2019)

■Contents

Free city excursion to Takayama city

■Booking information

Participants do not need to book in advance (free excursion).

■Detailed city information

Takayama is a local city in the mountainous Hida region of Gifu prefecture, Japan, and is well known for its rich nature and history. In particular, the old town, so-called little Kyoto, located in the heritage preservation area, is one of the most famous sightseeing spots. Please see the following web site for detailed information: tourist information http://www.hida.jp/english/

Program

	Start	End	
Day 1 Oct. 2 Wed.	9:00	10:30	Registration
	10:30	10:45	Opening remarks
	10:45	12:35	20th anniversary session: Review and future perspective
	12:35	13:45	Lunch
	13:45	15:15	Soil ecology and biochemistry
	15:15	15:30	Group photo
	15:30	15:50	Coffee break
	15:50	17:30	Remote sensing
	17:35	18:25	20th anniversary ceremony
	19:00	21:00	Banquet (Festa Forest in Takayama)
Day 2 Oct. 3 Thu.	9:00	11:10	Flux measurements and multi-site synthesis
	11:10	11:25	Coffee break
	11:25	13:00	Trace gases
	13:00	14:05	Lunch
	14:05	16:05	Poster session
	16:05	16:15	Coffee break
	16:15	17:45	Modelling
	18:00	20:00	AsiaFluxSSC and Young Scientist Meeting
Day3 Oct. 4 Fri.	9:00	10:40	Ecosystem processes
	10:40	10:50	Coffee break
	10:50	12:50	Poster session
	12:50	14:00	Lunch
	14:00	15:20	20th anniversary session: Linking scientific communities & Linking science and society
	15:20	15:30	Coffee break
	15:30	16:30	General discussion
	16:30	16:50	Closing remarks
Day4 Oct. 5 Sat.	8:00	13:00	Excursion to Takayama site
	Free	Free	Excursion to Takayama city (Free)

Detailed Program

	Start	Title	Speaker
Day 1	9:00	Registration	
Oct. 2	10:30	Opening remarks	
		20th anniversary session: Review and future perspective	
	10:45	A brief explanation of "20th anniversary session: Review and future perspective"	Kazuhito Ichii
	10:50	A-1: Look back the history of tower flux observation in Asia	Ryuichi Hirata
	11:05	A-2: Progress in water and energy flux studies in Asia: flux measurements and multi-site synthesis	Minseok Kang
	11:20	A-3: Soil respiration research in Asian region	Liqing Sha
	11:35	A-4: Volatile organic compound exchange between terrestrial ecosystems and atmosphere	Akira Tani
	11:50	A-5: Scaling between leaf photosynthesis and ecosystem GPP in Asian forests	Shih-Chieh Chang
	12:05	A-6: Remote sensing monitoring of terrestrial ecosystems in Asia: review and future perspective	Hideki Kobayashi
	12:20	A-7: Model studies for mining flux data: empirical, process-based, and machine learning	Akihiko Ito
	12:35	Lunch	
		Soil ecology and biochemistry Chair: Munemasa Teramoto	
	13:45	S-1: Soil CO_2 fluxes and global change: data and statistical approaches to better understand regional and global scale soil carbon dynamics	Benjamin Bond-Lamberty
	14:15	S-2: Long-term soil warming effect on soil organic carbon decomposition in Asian monsoon forests	Munemasa Teramoto
	14:30	S-3: Temperature sensitivity of soil respiration across multiple time scales in a temperate plantation forest	Tao Yan
	14:45	S-4: Nitrogen addition effects on SOM stability, and CO_2 and N_2O efflux in a tropical rainforest and rubber plantation in SW China	D. Balasubramanian
	15:00	S-5: Continuous measurements of soil CO_2, CH_4 and N_2O fluxes during the spring thawing period in broad-leaved Korean pine mixed forest of Changbai Mountains	Chuying Guo
	15:15	Group photo	
	15:30	Coffee break	

Day 1		Remote sensing Chair: Hideki Kobayashi	
Oct. 2	15:50	R-1: Phenological Eyes Network (PEN): a platform supporting AsiaFlux remote sensing activity by long-term continuous in-situ spectral / imaging observations	Kenlo Nishida Nasahara
	16:10	R-2: Breathing Earth System Simulator (BESS) as a flexible and scalable platform to monitor land-atmosphere fluxes from plot to the global scales	Youngryel Ryu
	16:30	R-3: Understanding species diversity and composition along successional and environmental gradients in a tropical secondary forest	Sawaid Abbas
	16:45	R-4: Relationship between surface dry conditions and carbon dioxide emission of forest fire in Far East Russia	Haemi Park
	17:00	R-5: RS-driven GPP model from eddy covariance flux data	Guangsheng Zhou
	17:15	R-6: Temporal dynamics of satellite-derived photochemical reflectance index (PRI) and solar-induced fluorescence (SIF) in climate-changing Mongolia	Tomoki Kiyono
	17:35	20th anniversary ceremony	
	19:00	Banquet (Festa Forest in Takayama)	

Day 2		Flux measurements and multi-site synthesis Chair: Hiroki Iwata	
Oct. 3	9:00	F-1: Experiences Measuring Methane Fluxes across a Meso-Network of Restored Fresh Water Wetlands, Rice and Irrigated Pastures in California, and Beyond	Dennis D. Baldocchi
	9:40	F-2: Temporal variation of methane fluxes and its biophysical drivers in a subtropical mangrove wetland	Jiangong Liu
	9:55	F-3: Greenhouse gas fluxes characteristics in small aquaculture ponds in Yangzi river delta of China	Mi Zhang
	10:10	F-4: Net ecosystem exchange of CO_2 from two land-uses on tropical peatlands in Sarawak, Malaysia	Frankie Kiew
	10:25	F-5: Radiation controls the interannual variability of evaporation of a subtropical lake	Wei Xiao
	10:40	F-6: Attribute parameter characterized the seasonal variation of gross primary productivity (αGPP): Spatiotemporal variation and influencing factors	Weikang Zhang
	10:55	Discussion	
	11:10	Coffee break	

Day 2		Trace gases Chair: Seiichiro Yonemura	
Oct. 3	11:25	A brief explanation of "Trace gases" session	Seiichiro Yonemura
	11:30	T-1: Applicability of a closed-path gas analyzer based on quantum cascade laser (QCL) spectrometers for EC flux measurements of N_2O and NO over a cropland	Kai Wang
	11:45	T-2: An open-path QCL-based sensor for fast and 0.5 ppbv sensitivity measurements of atmospheric ammonia	Yin Wang
	12:00	T-3: A mass spectrometric observation of multiple soil gas fluxes with a portable ultra-high resolution mass spectrometer (MULTUM) coupled with an automatic chamber	Noriko Nakayama
	12:15	T-4: Observation of vertical profiles of NO, O_3, and VOCs to estimate their source and sink distributions by inverse modelling in a Japanese larch forest	Ryuichi Wada
	12:30	T-5: Biogenic volatile organic compound emission from Tokyo urban area, Japan	Yutaka Kokubu
	12:45	T-6: Leaf uptake of monocyclic aromatic hydrocarbons by plants	Akira Tani
	13:00	Lunch	
	14:05	Poster session	
	16:05	Coffee break	
		Modelling Chair: Kazuhito Ichii	
	16:15	M-1: Making full use of hyperspectral data for gross primary productivity estimation with multivariate regression: mechanistic insights from observations and process-based simulations	Benjamin Dechant
	16:30	M-2: Modeling soil GHG emission from Changbai Mountain forest ecosystem by Forest-DNDC	Shu Ye
	16:45	M-3: Measurement and modeling of nitrous and nitric oxide emissions from a tea field in subtropical central China	Yong Li
	17:00	M-4: Carbon flux estimation in South Korea using eddy covariance, remote sensing, and support vector regression	Sungsik Cho
	17:15	M-5: Estimating high-latitude methane fluxes based on the satellite data-driven Terrestrial Carbon Flux Model	Ji Luo
	17:30	M-6: Exploring the mechanisms controlling the seasonality and the trend in global LAI during 2001-2017	Shaoqiang Wang
	18:00	AsiaFlux SSC and Young Scientist Meeting	

Day 3		Ecosystem processes Chair: Hiroyuki Muraoka	
Oct. 4	9:00	E-1: Nitrogen biogeochemistry in a forest ecosystem under changing climate – Challenge and opportunity of Long-Term Ecological Research	Hideaki Shibata
	9:20	E-2: Revealing the relationship between tree diversity and ecosystem functions through long term and nationwide datasets	Masae Ishihara
	9:40	E-3: Long-term soil warming experiment in a northern cool-temperate forest in Tomakomai, Hokkaido Japan - What was clarified or still unknown?	Tatsuro Nakaji
	10:00	E-4: Maximum carbon uptake rate dominates the interannual variability of global net ecosystem exchange	Zheng Fu and Shuli Niu*
	10:20	E-5: Development of long-term and multidisciplinary research and networking in forest ecosystems of Takayama site	Hiroyuki Muraoka
	10:30	Discussion	
	10:40	Coffee break	
	10:50	Poster session	
	12:50	Lunch	
		Linking scientific communities & Linking science and society Chair: Ryuichi Hirata	
	14:00	A brief explanation of "20th anniversary session: Linking scientific communities & Linking science and society"	Ryuichi Hirata
	14:05	L-1: Contribution to FLUXNET and collaboration across regional networks – recent directions and developments	Dario Papale
	14:30	L-2: Earth system modeling and expectations for future collaboration with AsiaFlux	Kaoru Tachiiri
	14:55	L-3: Climate science and social values	Seita Emori
	15:20	Coffee break	
	15:30	General discussion (includes 5 min presentation from each session)	
	16:30	Closing remarks	
Day 4	8:00	Excursion to Takayama site (-13:00)	
Oct. 5	Free	Excursion to Takayama city (Free)	

Poster Presentations (Day 2)

Poster presentations on Day 2 are registered to poster award competition except P1-O1 and P1-O2.

Poster Number	Title	Presenter
	Flux measurements and multi-site synthesis	
P1-F1	Year-round measurements of methane and carbon dioxide fluxes in two urban landscapes	Tsugumi Takano
P1-F2	Seasonal dynamics of carbon uptake and release and their climate controlling factors in the North Hemisphere terrestrial ecosystems	Lang Han
P1-F3	Attribution of Lake Taihu evaporation change simulated by CLM4-LISSS model on the basis of future scenarios data	Zhen Zhang
P1-F4	Seasonal and interannual variations in carbon fluxes in East Asia semi-arid grasslands	Huichen Zhao
P1-F5	An evaluation of the flux-gradient and the eddy covariance method to measure CH_4, CO_2, and H_2O fluxes from small ponds	Jiayu Zhao
P1-F6	Driving factors of changes in evapotranspiration from a red pine ecosystem	Takumi Suzuki
P1-F7	The controlling factors of diffusive and ebullitive methane emission on sub-daily time scale at a mid-latitude shallow lake	Tsukuru Taoka
P1-F8	How to register your observation data to European Flux Database?: Toward open data policy of JapanFlux data	Hina Yamanuki
P1-F9	Exploring influences of different management strategies on surface energy patterns in tea fields	Siang-Heng Wang
P1-F10	Inter-annual variability of net ecosystem exchange of CO_2 in a temperate deciduous forest in the Gwangneung National Arboretum in Korea	Hyunyoung Yang
	Soil ecology and biochemistry	
P1-S1	Soil respiration after six years of continuous drought stress in the tropical rainforest in Southwest China	Liguo Zhou

P1-S2	Nitrogen addition decreased soil respiration by altering microbial composition without changing the temperature sensitivity in a semiarid grassland	Wei Du
	Trace gases	
P1-T1	Isoprene emission from bamboo species	Tingwei Chang
	Ecosystem processes	
P1-E1	The effect of lost canopy on the seasonal variation of stem surface respiration in Japanese cedar	Haruna Takahashi
P1-E2	Eddy covariance reveals the seasonal patterns in energy balance and evapotranspiration from an alpine *Sphagnum* peatland in the Australian Alps	Meeruppage Dilani Manjula Gunawardhana
P1-E3	Does decomposition of leaf mixtures and absorptive-root mixtures synchronously change with deposition of nitrogen and phosphorus	Lei Jiang
P1-E4	Gas exchange process during and after rainfall over a Japanese cypress canopy by using eddy covariance and SVAT multi-layer model	Linjie Jiao
P1-E5	Tree root exudation with fine root traits under four coniferous forests in Japan	Maiko Akatsuki
P1-E6	Response of fine root respiration rate and morphology traits along the elevation gradient in Japanese subalpine forest	Mizuki Okamoto
P1-E7	Flower litters as hyper nitrogen- and phosphorus-rich resources for soil ecosystem	Kazuhide Ohta
	Remote Sensing	
P1-R1	Ground based measurement of solar-induced chlorophyll fluorescence dynamics in rice paddy field ecosystem	Kanokrat Buareal
P1-R2	Mapping the forest aboveground biomass in Japan by SAR-based machine learning model	Lan Wu
P1-R3	Precipitation-use efficiency in Eurasian steppe region: spatial pattern and influence factors	Tianyou Zhang
P1-R4	Determination of parameters for evergreen broadleaf forests in gross primary production capacity estimation algorithm using flux data for Amazon, Thailand and Australia	Aika Wakai
P1-R5	Long-term observation of the photochemical reflectance index (PRI) and light-use efficiency (LUE) in a temperate Japanese cypress forest at Kiryu Japan	Siyu Chen

P1-R6	Detecting vegetation changes induced by afforestation and land use change in China using multiple satellite products	Takuto Taguchi
P1-R7	Data Driven GPP and NEE Estimation with Lag Effect, Remote Sensing and Machine Learning	Zhiyan Liu
P1-R8	Changes in terrestrial carbon cycle in Mongolia: Synthesis analysis	Zaya Mart
P1-R9	Using the BRDF corrected photochemical reflectance index to track light use efficiency for subtropical evergreen mixed forest	Li Ma
P1-R10	Developing a Machine Learning based Flowering Detection and Quantification Algorithm using Time-Series Image Data	Tae Kyung Kim
P1-R11	Lidar-derived canopy structure of restored temperate wetlands	Robert John Shortt
	Modelling	
P1-M1	Estimation of greenhouse gas budget over high-latitude ecosystems using a process-based ecosystem model, VISIT	Mikita Okamura
P1-M2	Latent heat and sensible heat flux simulation in tropical peat swamp forest using artificial neural network	Edward Baran Aeries
P1-M3	Flood risk assessment in Bangladesh, India and Myanmar based on the AHP weight method and entropy weight method	Yuanyuan Liu
P1-M4	Freezing injuries impact carbon and water use efficiency by leaf area index of natural zonal terrestrial vegetations in Inner Mongolia between 2004 and 2015	Pengyuan Wang
	Others	
P1-O1	Field-scale productivity and water use of a high-yielding rice cultivar	Hiroki Ikawa
P1-O2	Field challenges of eddy covariance measurement in tropical peat ecosystems in Sarawak, Malaysia – The TROPI experience	Joseph Wenceslaus Waili

Poster Presentations (Day 3)

Poster Number	Title	Presenter
	Flux measurements and multi-site synthesis	
P2-F1	Net ecosystem CH_4 exchange of three tropical peat ecosystems in Sarawak, Malaysia	Guan Xhuan Wong
P2-F2	Biophysical controls on the variability of ecosystem-scale CO_2 exchange in a Bornean peat forest	Angela Che Ing Tang
P2-F3	Evapotranspiration from three tropical peat ecosystems in Sarawak, Malaysia	Kevin Kemudang Musin
P2-F4	Patterns and controls of light use efficiency in four contrasting forest ecosystems in Yunnan, Southwest China	Yiping Zhang
P2-F5	The forest-atmosphere carbon dioxide and methane exchanges in Indian tropical mangrove ecosystem	Gnanamoorthy Palingamoorthy
P2-F6	Ecological effect of fog on carbon and water exchanges in tropical rainforest and sub-tropical evergreen forest, Southwest China	Gnanamoorthy Palingamoorthy
P2-F7	Estimation of surface carbon dioxide exchange over rubber tree plantation in Thailand using area-averaged flux method	Chompunut Chayawat
P2-F8	Latest in flux data analysis software: from quality control and gap filling to flux and footprint partitioning	George Burba
P2-F9	Illustrative maps of past and present eddy covariance measurement locations: II. High-resolution images	George Burba
P2-F10	Spectroscopic Effects in Laser-based Eddy Covariance Flux Measurements	George Burba
P2-F11	Factors influencing the variation of CO_2 flux and evapotranspiration in larch forest ecosystem affected by the extreme wet-soil condition	Ayumi Kotani
P2-F12	Twenty years of carbon monitoring at Sapporo forest meteorology research site in the northern part of Japan	Yasuko Mizoguchi
P2-F13	Seasonal variations of methane flux in tropical peat swamp forest in Indonesia	Ayaka Sakabe
P2-F14	Estimation of surface soil water contents by combining water balance model with machine-learning based evapotranspiration estimates and its comparison with process-based approach	Juhan Park

P2-F15	Dissolved carbon transportation and CO_2 emissions in main rivers of the Tibetan Plateau	Bin Qu
P2-F16	Atmospheric deposition of nitrogen, phosphorous, and acid in Chinese ecosystems: dynamics, patterns, and the influencing factors	Qiufeng Wang
P2-F17	18 years to compensate all CO_2 emission after a clearcut harvesting in a cool-temperate forest	Kentaro Takagi
P2-F18	The influence of precipitation pulses on surface energy balance and evapotranspiration over an arid shrubland	Xibin Ji
P2-F19	Long term variation of CO_2 flux at cool temperate red pine forest in Japan	Yuji Kominami
P2-F20	Long-term variations in the carbon budget and the atmospheric CO_2 concentration detected from 26-year observation in a cool-temperate deciduous forest at Takayama	Shohei Murayama
P2-F21	Simulation of methane dynamics in a mid-latitude eutrophic lake with constraints using incubation data	Hiroki Iwata
P2-F22	Reanalysis of 20 years data at TKY	Hiroaki Kondo
P2-F23	Discrepancy in phonological indicators derived with CO_2 flux, MODIS image and ground monitor at a temperate mixed forest and an alpine shrub ecosystem	Leiming Zhang
P2-F24	Assessing the net carbon flux to the atmosphere from land-use change in tropical peatland- the new emissions that the atmosphere will see	Chandra Shekhar Deshmukh
P2-F25	The greenhouse gas and energy balance of a commercial oil palm plantation in tropical lowland Jambi province (Sumatra, Indonesia)	Christian Stiegler
P2-F26	The differences of net ecosystem production changes between *Pinus koraiensis* plantation and mixed forest over four years after drought event	Hyun Seok Kim
P2-F27	Carbon dioxide exchanges over the secondary dry dipterocarp forest in Thailand as affected by the 2015/2016 strong El Nino	Rungnapa Kaewthongrach
P2-F28	Inter-annual variations in carbon sequestration of Inner Mongolia semi-arid grasslands	Shiping Chen
P2-F29	Ecosystem Carbon and Nitrogen Dynamics of Tropical Peatland (ECaNDoTP): Cross-site comparison of trace gas exchange between managed tropical peatlands in mainland and insular Malaysia	Lip Khoon Kho

Soil ecology and biochemistry		
P2-S1	Soil CO_2 fluxes in a tropical lowland ever-green secondary forest in Pahang, Peninsular Malaysia	Jeyanny Vijayanathan
P2-S2	Analysis of soil characteristics of the agrometeorological observatories in Korea for the production of high quality soil moisture data	Sung-Won Choi
P2-S3	Development of reference soil moisture measurement system for calibration of soil moisture sensor	Jongho Kim
P2-S4	Soil respiration rates of Japanese cypress (*Chamaecyparis obtusa* Endlicher) stands regenerated from a pine wilt disease forest	Gyeongwon Baek
Trace gases		
P2-T1	Seasonal variations of isoprene and monoterpenes concentrations in six forests between cool temperate and subtropical zone in Japan	Takafumi Miyama
P2-T2	NO emission from tropical and polar soils	Seiichiro Yonemura
P2-T3	Effect of growth temperature on monoterpene emission rates of *Acer palmatum*	Tomoki Mochizuki
Ecosystem processes		
P2-E1	The effect of canopy phenology and canopy surface physical phenomena on carbon budget in evergreen coniferous and deciduous broad-leaf forests in a cool-temperate region under ongoing climate change	Taku M. Saitoh
P2-E2	Characteristics and Scenarios Projection of NEE Change on the Tibetan Plateau	Mingyuan Du
P2-E3	Quantification of water usages of man-made oasis and natural vegetation in the middle part of Hexi corridor, northwestern China	Wenzhi Zhao
P2-E4	The variation of carbon dioxide flux and response to the water level changes over a large ephemeral lake	Xiaosong Zhao
P2-E5	Hydraulic characteristics and water storage of Japanese cypress using sap flow rate and water potential measurements	Mai Kamakura
P2-E6	Contribution of whole-tree water storage to daily transpiration in conifer trees	Wakana Azuma
P2-E7	Long-term soil warming effect on insect-plant interactions at the canopy of tall oak trees	Masahiro Nakamura

Remote Sensing		
P2-R1	The temporal variation of Solar Induced Fluorescence detected by the canopy spectroscopy in cool-temperate broadleaf deciduous forest in central Japan	Tomoki Morozumi
P2-R2	High temporal monitoring of terrestrial CO_2 fluxes using geostationary satellites	Kazuhito Ichii
P2-R3	Estimation of carbon dioxide emissions through tropical peatland subsidence using interferometric synthetic aperture radar analysis	Tomohiro Shiraishi
P2-R4	Measuring landscape albedo using unmanned aerial vehicles	Chang Cao
P2-R5	High-Frequency estimation of the land surface temperature using next-generation geostationary satellite data	Yuhei Yamamoto
P2-R6	GPP capacity estimation algorithm using light response curve in various vegetation types for global observing satellite data	Kanako Muramatsu
P2-R7	Phenological changes in *in-situ* and GOSAT-based SIF in evergreen coniferous forest in Japan	Hibiki M. Noda
P2-R8	Ground based measurements of aerosol properties for estimating biophysical parameters by using optical Earth observation data	Hirokazu Yamamoto
Modelling		
P2-M1	Spatio-temporal variability in N_2O emissions from a tea-planted soil in subtropical central China	Xinliang Liu
P2-M2	Rubber yield estimation using net ecosystem production (NEP)	Duangrat Satakhun
P2-M3	A global carbon cycle model system for the GOSAT-2 project	Makoto Saito
P2-M4	Effects of mortality in a long-term carbon budget modeling	Katsumi Yamanoi
P2-M5	Applicability of daily evapotranspiration models of spring maize based on eddy covariance	Qijin He

Abstracts: Oral Presentations

A-1

Look back the history of tower flux observation in Asia

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Asia region is distributed under wide climate zone from tropical through temperate to boreal.According to the climate zone, there are various types of terrestrial ecosystems such as many types of forests, paddy fields, crop lands, grass lands, wetlands, desert and tundra. Population and GDP in Asia accounts for 60% and 30% of the world, respectively and land use changes such as farming, deforestation/afforestation are increasing with increase of population and GDP. Both climate and human activity strongly affect on carbon dynamics and water balance of terrestrial ecosystems. In order to clarify it, long term flux observation using eddy covariance technique with towers had started.

First long-term flux observation started in Takayama site, Japan from 1994 (Saigusa et al., 2002, 2005). From 1994 to 1997, aerodynamic method was used and observation using eddy covariance technique started from 1998 and it was still the oldest data in Asia. In early 2000s, many long-term flux observations were started, and they are mainly initiated by Japan, Korea and China. In late 2000s to early 2010s, researchers in Philippine, Thailand, Malaysia, Indonesia and India started long-term flux observations. Now, in 2019, 108 sites are registered in AsiaFlux and data of 38 sites are registered in AsiaFlux Data.

Before long-term flux observation started, diurnal variations in flux during several days or several month and analyzed the relationships between CO_2 flux and environmental factors using limited data. Long-term flux observations allow us to divide NEE into GPP and RE, to know annual values of them and to clarify seasonal and inter-annual variations in them. We can also analyze seasonal and inter-annual changes in relationship between carbon balances and environmental factors. Effects of extreme climate such as ENSO were able to be detected by long-term observations. Several sites were affected by disturbances and it clarified the effect of disturbance on carbon balances.

Several years data in each site had been stored, site-inter comparison studies had been available. These studies clarified what kind of environmental factors affected on carbon balances of terrestrial ecosystems in Asia. In late 2000s, open-path sensor for CH_4 density was spread and CH_4 flux observations using eddy covariance method started in wetlands.

In this presentation, I will review long-term flux observations in various types of terrestrial ecosystems, synthesis analysis using such kind of data.

Progress in water and energy flux studies in Asia: flux measurements and multi-site synthesis

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In the past three decades, global (i.e., FLUXNET) and several regional networks (e.g., AmeriFlux, AsiaFlux, ICOS, OzFlux) of eddy covariance technique based tower flux measurements have been continuously growing and are now better distributed to represent diverse plant functional types in various climates, enabling the regional assessment of spatiotemporal variability of surface fluxes. The history of AsiaFlux (i.e., the continental network of tower flux measurements in Asia, http://www.asiaflux.net) is relatively short compared to those of Europe and North America. The number of flux measurement sites in Asia, however, has increased to over a 100, and more multi-year observation data are now available and are used for synthetic analyses and validations for various models and satellite algorithms. In this presentation, we will review the progress in water and energy flux studies in Asia from the 1990s to the present (Fig. 1) including continuous evapotranspiration and surface energy balance measurements in various ecosystems (e.g., forest, cropland, urban, lake) from the tropics to the polar regions, inter-comparison experiments between eddy covariance system and the other observation techniques (e.g., lysimeter, scintillometer), data processing techniques (e.g., partitioning, gap-filling), model-data fusion (e.g., calibration and validation of land surface-hydrology model), evapotranspiration mapping based on satellite remote sensing, and inter-linkages of carbon and water fluxes.

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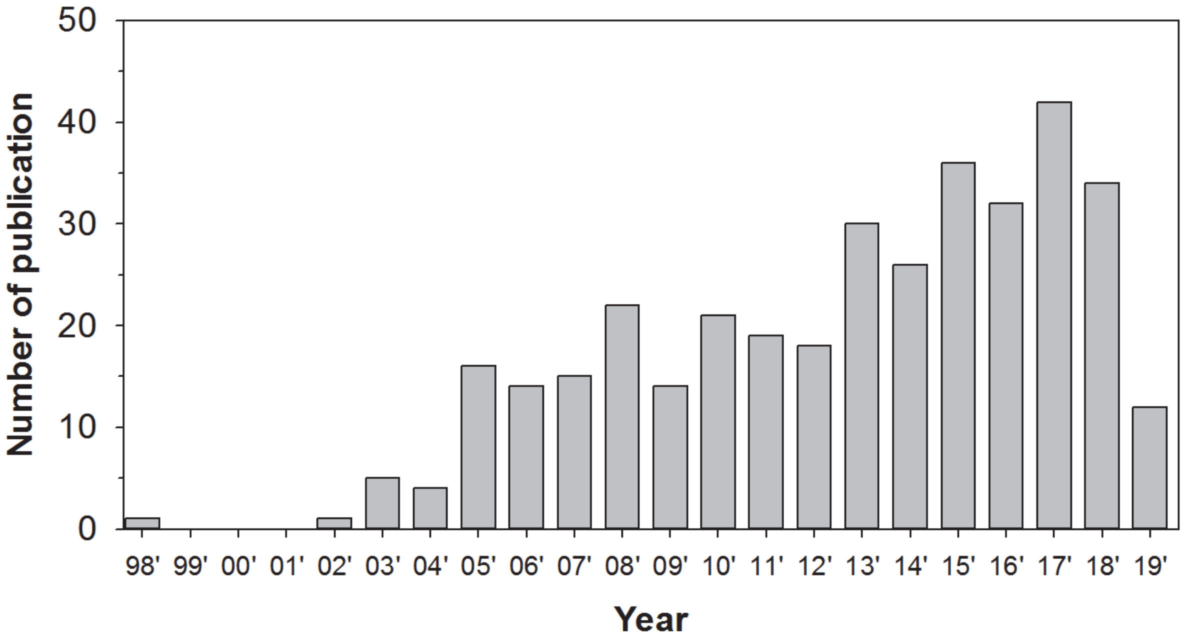

Fig. 1. The AsiaFlux publication related to evapotranspiration and/or energy flux from 1998 to 2019. (Peer-reviewed international journal only, Source: Scopus database, https://www.scopus.com)

A-3

Soil respiration research in Asian region

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Soils are the largest carbon pool in terrestrial ecosystem, which contain about twice the carbon present in the atmosphere, and almost triple in the plants. Uptake of carbon by terrestrial primary production approximately equals return to atmosphere by soil and plant respiration. Therefore, soil respiration plays an important role in global carbon balance.

In this presentation, we reviewed soil respiration study in the last two decades in Asian region. We introduced background, methods of soil respiration, achievements in tropical forest, subtropical forest, temperate forest, glass land, peat land. We discussed climate change, disturbance and long term experiments of controlled water and temperature on soil respiration. Finally, we stressed the importance of controlling mechanisms, multiple factors (C, N, H2O, microbes), model development and validation in future study.

A-4

Volatile organic compound exchange between terrestrial ecosystems and atmosphere

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Large amounts of volatile organic compounds (VOCs) are emitted from anthropogenic and biogenic sources. Their concentrations in the atmosphere are very low, typically ppbv or less than ppbv levels. However, through some chemical decomposition process, they contribute to the production of photochemical oxidants including ozone. Ozone degrades air quality and has negative impacts on human, other animals and plants. If a compound group of VOCs is highly reactive in the atmosphere, its contribution to the ozone formation is significant.

Plants are known to absorb some inorganic gas species including CO_2. Recent study has showed that trees can absorb some groups of VOCs through stomata. In this presentation, the recent progress on the VOC uptake study will be reviewed. VOC removal by plants may be able to decrease VOC concentration in the atmosphere and, as a result, can reduce the ozone-forming reaction frequency.

On the other hand, plants produce and release some VOCs. Terpenoid is a group produced by plants. Among terpenoid compounds, isoprene (C_5H_8) is highly volatile and emitted from many broad-leaved trees. Monoterpene is the general name of compounds having the molecular formula of $C_{10}H_{16}$. Typically, more than 20 compounds are detected in forest atmosphere. Most of them are highly reactive in the atmosphere and more or less contribute to producing the photochemical oxidants and secondary organic aerosols (SOAs). SOAs may directly and, by producing cloud condensation nuclei, indirectly reflect sun light and is believed to have suppressing effect on global warming. However, study regarding SOAs still has large uncertainty. It is shown by several reports that the annual emission of the terpenoids on global scale is estimated to be higher than that of anthropogenic VOCs. Because of its high reactivity and large amount of their emissions, many researchers have been addressing these compounds. Major concerns regarding the compounds are effects of environmental factors including temperature, drought, ozone, CO_2, and other factors on terpenoid emission, effect of land use change on its emission and regional atmospheric chemistry and climate, and interaction between future climate change and its global emission. The methods to measure terpenoid emission from plants are leaf cuvette method for individual leaves, branch enclosure method for tree branches, and tower flux measurement methods for forest and crop canopies. The flux measurement methods include relaxed eddy accumulation (REA) and eddy covariance methods. Here the recent progress of the terpenoid emission study will be reviewed.

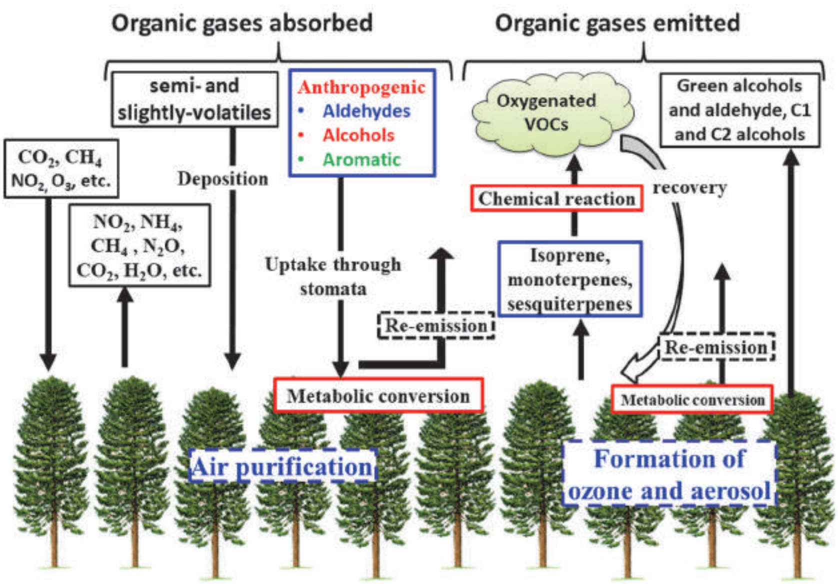

Figure Volatile organic compound exchange between terrestrial ecosystems and atmosphere

A-5

Scaling between leaf photosynthesis and ecosystem GPP in Asian forests

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Photosynthesis by all the terrestrial plants is the biochemical reaction that converts the atmospheric CO_2 into organic carbon that ultimately feeds the terrestrial biosphere. Because of this unprecedented importance, photosynthesis is the only process that has been studied across more than 13 order of magnitude in space from nano-scale molecular biology to the global-scale carbon flux of gross primary production (GPP). For the flux community, the core question in terms of photosynthesis is the quantification of photosynthetic carbon flux and the identification of its controlling mechanisms at the scales from leaf up to the globe. Those knowledges allow the construction of mechanistic models of ecosystem carbon fluxes and thus enable the projection of future carbon budget that will determine the future climate change pathway. The several decades of flux tower measurements around the globe, including the AsiaFlux sites, have accumulated large amount of ecosystem net ecosystem carbon exchange (NEE) data by the eddy covariance methodology. From the daytime NEE data, GPP can then be derived through different algorithms with unavoidable high uncertainties. Though the current knowledge about ecosystem GPP is mainly based on this indirect way of measurement, the flux site GPP values are widely used for ground-truthing in satellite remote sensing and for model validation. Some flux sites have conducted independent measurements of leaf-scale photosynthesis besides the eddy covariance method. Most of these leaf-scale measurements are used for understanding the characteristics of photosynthesis and for deriving parameters such as the maximum carboxylation rate of the enzyme Rubisco. These parameters are used for creating models that calculate larger scale carbon budgets. In this case, the simulated values will be validated by the measured flux data. Only very few flux sites have tried to compare the NEE-derived GPP with the photosynthesis rate measured at the leaf scale. The measurement of photosynthesis at the leaf scale, and the scaling between leaf and ecosystem scales of eddy flux measurements, might deserve more attention in flux community.

A-6

Remote sensing monitoring of terrestrial ecosystems in Asia: review and future perspective

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In the past fifty years, Asian countries have achieved remarkable successes in economy and social development. The time of this rapid social development in Asia was fully overlapped with the history of Earth observation by satellites after the success of Landsat-1 in July 1972. Remote sensing data have been recorded various environmental changes during this rapid Asian growth e.g. land cover change, forest/grassland degradation and deforestation, wildfires and smokes, permafrost degradation. Temporal monitoring of ecosystem structures and functions (e.g. biomass, phenology, photosynthesis) is also key information in the context of regional carbon managements under future warming climate. On the other hand, remote sensing observations are always suffered from "noise due to atmospheric particles" when looking at land surfaces. In addition, remote sensing quantities are only limited in outgoing electromagnetic waves and are insufficient to understand the flows of carbon and water in the terrestrial ecosystems. In this review, we highlight the remote sensing monitoring in Asia emphasizing a close relation with the AsiaFlux observation network.

A-7

Model studies for mining flux data: empirical, process-based, and machine learning

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2 Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan
3 Chiba University, Chiba, Japan

Advancing data–model fusion is an important issue for flux community including AsiaFlux. Even in the most observation-oriented studies, we need to use models for data correction, gap-filling, and foot-print analysis. In addition to empirical or statistical models, more biological and micrometeorological models have been developed and used to derive further insights in conjunction with flux measurement data.

One well-known example is the multi-layer canopy model, in which vertical transfers of energy and materials are explicitly resolved on the basis of biophysical principles. The multi-layer models, even though horizontal heterogeneity is ignored or simplified, help us to understand turbulent diffusion processes in boundary layer and canopy air space and ecophysiological mechanisms such as vertical gradient of leaf properties. Most of multi-layer models include a biochemical photosynthesis scheme coupled with a parameterization of stomatal conductance, allowing us to conduct biologically in-depth analyses but in most cases at short-term spans.

Another kind of models, i.e. process-based or dynamic vegetation models, utilize the flux measurement data at longer time spans. These models were developed to simulate carbon cycling in ecosystems at annual to centennial scales, and then flux data were firstly used for model validation in terms of seasonal and interannual variability of atmosphere–ecosystem CO_2 exchange. The growing amount of flux data so far enabled us to conduct model validation across multiple biomes and at decadal time scale. In turn, these ecosystem models have provided opportunities to flux studies. First, these models clarified necessities to elucidate underlying mechanisms that determine fluxes. For example, process-based model studies have revealed the importance of leaf phenology in determining fluxes of deciduous biomes in a quantitative manner. Second, these models allowed us to integrate different ecosystem components into a comprehensive framework. Namely, while the multi-layer models well capture canopy processes, the ecosystem models account for both above- and below-ground processes though at lower time-step and accuracy. The models allow us to evaluate the contributions of plant roots, microbes, and soil organic matter. Third, these ecosystem models explicitly consider the carbon stock change, allowing us to simulate long-term structural ecosystem development and associated flux change. This is particularly advantageous for making future projections under different environmental change scenarios, and several recent studies use dynamic vegetation models to account for the longer-term changes in ecosystem structure. By using AsiaFlux data, a number of models have been developed and used for specific studies, including those aimed at elucidating broad-scale carbon budget.

One contemporary direction of data–model fusion is the data assimilation, in which model state variables and parameters are (sequentially) optimized by using observational data and certain mathematical algorithms. For example, parameters related to leaf phenology were optimized to correctly retrieve seasonal change in leaf area index. Data assimilation is promising for integrating a variety of observational data such as flux, biometric, and satellite remote sensing data into a single model framework. Similar to other regions, assimilation of solar-induced chlorophyll fluorescence data into an ecosystem model is ongoing at AsiaFlux sites. Recently, new numerical methodologies, i.e. machine learning or artificial intelligence, are rapidly growing in every research area. One relevant example is the global upscaling of flux measurement data, which have a limited extent of spatial representativeness, allowing linkage with global-scale modeling and Earth observation by remote sensing. Although present attempts indicate not only possibility but also problems in the methodology, machine learning will provide research opportunities and allow us to derive practical insights from flux measurement data.

Global flux network has allowed us to clarify regional characteristics and necessity of region-specific model studies: e.g., paddy field models to simulate methane fluxes. We review status-quo and problems and then discuss future opportunities in flux data–model studies, especially from the perspective of AsiaFlux and social contributions.

S-1

Soil CO_2 fluxes and global change: data and statistical approaches to better understand regional and global scale soil carbon dynamics

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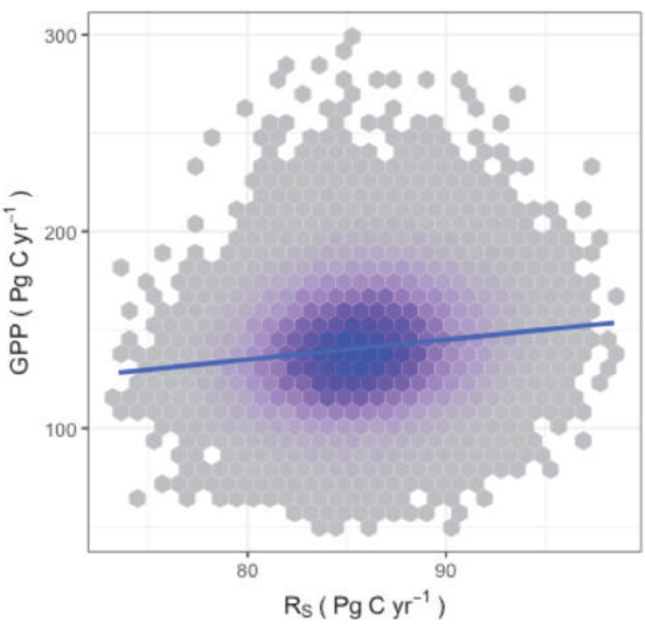
Globally, soils store two to three times as much carbon as currently resides in the atmosphere, and it is critical to understand and predict how they will respond to ongoing climate change. Our ability to detect and confidently attribute changes in soil carbon fluxes such as soil respiration is uncertain, however, as is the very magnitude of major fluxes in the global carbon cycle. We examine the probability of observing climate-driven changes in heterotrophic soil respiration (R_H), how likely it is that our current estimates of R_H and primary production are consistent, and what types of data, databases, and analyses are most likely to advance this science. We situate these analyses within the context of ongoing changes in the global carbon cycle, discussing the implications with respect to the Asian region and AsiaFlux community.



S-2

Long-term soil warming effect on soil organic carbon decomposition in Asian monsoon forests

Munemasa Teramoto*[1], Naishen Liang[1], Kentaro Takagi[2], Toshiaki Kondo[3], Jun Koarashi[4], Mariko Atarashi-Andoh[4], Takashi Hirano[5], Yoshiyuki Takahashi[1], Masahiro Takagi[6], Sachinobu Ishida[7], Masaaki Naramoto[8], Yiping Zhang[9, 10], Derrick Yuk Fo Lai[11], Po-Neng Chiang[12], Jiye Zeng[1], Shilong Piao[13], Shenggong Li[14], Hajime Tomimatsu[1], Zhao Xin[1], Kaneyuki Nakane[15], Yan Tao[13], Tze-Leong Yao[16], Samsudin Musa[16]

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Soil respiration (R_s) consists of root respiration and heterotrophic respiration (R_h, decomposition of soil organic carbon by soil microbiota). Globally, R_s is estimated as 98 GtC yr^{-1}, and R_h contributes more than the half of R_s. Because R_h exponentially increases along with the rise of temperature, it is concerned that increased R_h under future warmer environment might be further accelerate global warming (positive feedback). Therefore, long-term response of R_h to global warming is one of the most important elements for precise prediction for future climate change. In addition, it is possible that magnitude and sustainability of the warming effect on R_h are different in each region depending on the climate and soil properties. Soil warming experiment in field is one of the effective methods to examine the long-term response of R_h against global warming. Building up long-term monitoring data for R_h under soil warmed environment in several ecosystems all over the world will contribute to precise prediction for the feedback of terrestrial ecosystems against global warming. However, such long-term monitoring data under warmed environment is totally limited, especially in Asian monsoon region. Asian monsoon region is rich in plant biomass and vegetation types, and feedback of this region is critical for global climate change. To examine long-term response of R_h in Asian monsoon forest soil, we installed the same multi-channel automated chamber measurement system in typical forests in Asian monsoon region, and we conducted several years of soil warming experiments. In this presentation, we show the long-term response of R_h against artificial soil warming and control factors for the seasonal and inter-annual variation of the warming effect on R_h in those several forest ecosystems.

Temperature sensitivity of soil respiration across multiple time scales in a temperate plantation forest

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Soil respiration (Rs) is the largest carbon (C) flux from terrestrial ecosystems to the atmosphere. Predictions of Rs and associated feedback to climate change remain largely uncertain, in part due to the high temporal heterogeneity of temperature sensitivity (apparent Q_{10}) of Rs under a changing climate. Therefore, it is of critical importance to provide better insight into how Q_{10} varies across multiple temporal scales. We investigated the diurnal, seasonal, and annual variabilities in the Q_{10} of Rs using continuous Rs measurements (at hourly intervals) over six growing seasons in a mature temperate larch plantation in North China. We found that night-time values of Q_{10} were slightly lower than daytime values. Large seasonal and annual fluctuations of Q_{10} were observed, as illustrated by high coefficients of variation of 15.0% and 21.8%, respectively. The higher Q_{10} in spring and autumn were primarily regulated by fine root growth and higher soil moisture after snow melt in spring, and leaf senescence in autumn. Lower Q_{10} in summer may have been caused by limitations in substrate availability and microbial activity resulting from drought, which also caused a decoupling of Rs from soil temperature in summer. Furthermore, a bivariate nonlinear model incorporating both soil temperature and soil moisture best explained Q_{10} variability. Generally, lower soil temperature and higher soil moisture lead to higher values of Q_{10}, indicating that climate warming could exert a negative effect on Q_{10}, partially offsetting the warming-induced increase in soil C loss. We provide long-term field experimental evidence that it would be inappropriate to estimate Rs on a multiyear scale using a fixed Q_{10} value or a value obtained from one season and/or one year. Thus, we emphasize the importance of incorporating the seasonal and annual heterogeneities of Q_{10} into C cycle model simulations under future climate change scenarios.

S-4

Nitrogen addition effects on SOM stability, and CO_2 and N_2O efflux in a tropical rainforest and rubber plantation in SW China

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The pressure to convert the natural forest area into rubber plantations and other land-uses can be widely observed Xishuangbanna. In order to increase and sustain the productivity of rubber plantations, nitrogen (N) fertilization is essential. However, it can be detrimental to soil fertility if applied in excess. Further, it is important to assess the effect of N addition on SOM stability and soil GHGs efflux to understand carbon (C) stability in tropical rainforest (TF) and rubber plantation (RP) soil. Hence, we have conducted a field N addition experiment to determine the N addition effect on soil SOM dynamics, CO_2 and N_2O efflux in a tropical rainforest and rubber plantation in Xishuangbanna. N addition significantly ($p < 0.05$) increased heavy fractions (HF), while decreasing free light and occluded light fractions under both TF and RP. N addition did not have any significant ($p > 0.05$) effect on CO_2 flux in TF. Contrarily, both CO_2 and N_2O flux were significantly higher under N fertilized plots in both TF and RP. Further, CO_2 and N_2O efflux showed a strong seasonal pattern, with the highest and lowest flux occurred during wet (May–October) and dry (November–April) season respectively. Soil CO_2 flux showed a significant ($p<0.05$) positive relationship with soil temperature and soil moisture under both TF and RP. However, soil moisture did not have any significant effect on CO_2 flux in rubber plantation. The results suggests that under the similar soil type and climatic condition, tropical rainforest and rubber plantation have different CO_2 and N_2O flux rates in response to N addition.

Continuous measurements of soil CO_2, CH_4 and N_2O fluxes during the spring thawing period in broad-leaved Korean pine mixed forest of Changbai Mountains

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This study was carried out in broad-leaved Korean pine mixed forest of Changbai Mountains (CBM). The main aims are to understand the dynamic changes and influencing mechanisms of greenhouse gases fluxes. We has acquired the flux data of CO_2, CH_4 and N_2O in situ for five years by using dynamic chambers. Continuous measurements provide more support to understand the responses of soil processes to the rapid changing environment. It becomes possible to realize the differences of these three kinds of greenhouse gases fluxes throughout the year and the contributions in temporal scale to the warming effect with dynamic chambers.

Soil CO_2, CH_4 and N_2O fluxes showed apparent seasonal variations. The results indicated that the thawing period has drawn attention to the huge soil N_2O emission in CBM. A rush-out of soil N_2O flux was observed during the beginning of spring. The data of soil CO_2, CH_4 and N_2O fluxes during non-growing season were rarely reported in the past. To increase the credibility of the data, comparison experiments were carried out with static-chamber method combined with the Gas Chromatography technique and soil CO_2 flux system (Li-8100) acknowledged to be common methods in soil respiration measurements during the spring thawing period. The measurements were also monitored intensively via increasing the sampling frequency, and a set of meteorological and soil environmental factors during soil thawing were analyzed. This presentation will show the characteristics of the fluxes of soil CO_2, CH_4 and N_2O in response to biotic and abiotic factors. It helps to better understand the patterns and mechanisms of soil CO_2, CH_4 and N_2O fluxes during the spring thawing period and estimate the carbon and nitrogen budget.

Phenological Eyes Network (PEN): a platform supporting AsiaFlux remote sensing activity by long-term continuous in-situ spectral / imaging observations

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The Phenological Eyes Network (PEN) started in 2003 as a network of flux sites equipped with in-situ remote sensing instruments. It was designed as a platform for validation and algorithm development of remote sensing of ecosystems by providing long-term in-situ data. In particular, PEN has been putting its focus on seasonal changes (phenology) and inter-annual change of vegetation.

There are three types of core sensors at PEN sites; an Automatic Digital Fish-eye Camera (ADFC), a HemiSpherical SpectroRadiometer (HSSR), and a Sun Photometer (SP). As of 2019, there are approximately 30 PEN sites, among which many are also FluxNet and/or International Long Term Ecological Research (ILTER) sites. The PEN is now part of a biodiversity observation framework. Collaborations between remote sensing scientists and ecologists working on PEN data have produced various outcomes about remote sensing and long-term in-situ monitoring of ecosystem features, such as phenology, gross primary production (GPP), and leaf area index (LAI) (Nasahara and Nagai, 2015).

Those PEN data have been used mainly for validation of moderate resolution satellites such as MODIS and SPOT-VEGETATION for more than 10 years. In addition, validation of phenology monitoring by geostationary satellite (Himawari-8) has begun. Meanwhile, to enable direct and precise comparison between satellite data and in-situ monitoring, some PEN sites have received new investments to cover a large footprint of satellite sensors such as MODIS and GCOM-C/SGLI, namely, 500 m x 500 m, by a support of Japan Aerospace Exploration Agency. In addition, recently PEN has been working for remote sensing of chlorophyll fluorescence (for application of GOSAT and GOSAT-2 satellites). Many of the PEN data are now getting open for public use.

Takayama (TKY) is one of the longest and the most invested site of PEN. By collaboration with ecology and flux scientists in TKY, and combination of PEN data with other data (satellite, flux, physiology, laser, etc.), PEN-TKY has been working as one of the model sites of scientific study of PEN.

Breathing Earth System Simulator (BESS) as a flexible and scalable platform to monitor land-atmosphere fluxes from plot to the global scales

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Satellite remote sensing enables us to monitor land-atmosphere processes across a range of spatial and temporal scales, but integrating multiple sources of remote sensing into a single platform remains a challenge. Here we present BESS as a flexible and scalable platform to monitor land surface processes from plot to the global scales. BESS is a process based model that couples atmospheric and canopy radiative transfer, canopy photosynthesis, transpiration, and leaf energy balance which are forced with multiple satellite remote sensing data. We report new modules, BESS-Rice, BESS-SiF, and BESS-Vcmax. BESS-Rice simulates rice growth development and yield by allocating canopy photosynthesis into grain, leaf, stem and root, which was evaluated at six site-years flux tower data in Korea. BESS-SiF computes canopy escaping SiF by coupling the Farquhar photosynthesis model with an established leaf model of SiF and an escape ratio scheme under the two-leaf canopy model, which was tested on tower-based, landscape and global scale SiF datasets. BESS-Vcmax is based on an optimality hypothesis, which was evaluated across space and time using TRY database. BESS is highly scalable depending on forcings. As one example, we report 30 m resolution BESS flux maps forced with fine resolution forcing datasets. We are incorporating more modules into BESS and enhancing spatial and temporal resolutions with more satellite datasets.

Understanding species diversity and composition along successional and environmental gradients in a tropical secondary forest

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Forests are dynamic ecosystems that undergo successional changes through natural or assisted growth. Mapping of forest structural changes and successional growth patterns across spatial and temporal scales play a pivotal role in reducing the limitation of measuring global carbon flux. The majority of secondary forest in Hong Kong has developed through structural succession on lands protected from fire since1945. A multi-scale multi-temporal object-based image analysis approach was applied on the sequentially remote sensing data from 1945 to 2014 to map the successional age and structural classes of the recovering forest. In addition, a vegetation census survey consisting of 28 quadrats (20 x 20 m) was collected and analyzed along topographic, soil and successional gradients to examine the importance of different environmental factors on species assemblages in the secondary forest. The results show that elevation divides the species composition into two components at the landscape level. However, the species composition was further distinguished by successional age groups, with median ages of 7, 20, 39, 61, and 70 years, at a localized scale. Furthermore, the forest at a higher elevation was found to be more diverse and had a markedly higher concentration of soil carbon relative to nitrogen. Although the secondary forest has attained a species richness comparable to or greater than the old growth forest sites, their composition is very different from the old growth forest stands in the study area. These results clearly show that there is an urgent need to introduce the late successional species either by facilitating natural succession or by artificial enhancement planting. Thus, for effective forest restoration, the roles of GIS and Remote Sensing are important in locating sites for assisting shrub encroachment, as well as for accelerating secondary succession where shrubland has already been established.

R-4

Relationship between surface dry conditions and carbon dioxide emission of forest fire in Far East Russia

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Forest ecosystem in cool to cold climate plays a role of major carbon absorber. The carbon storage of those ecosystems is known as about twice of tropical forests. Positive feedbacks of the disturbances of forests to the global warming are reported many previous studies recently. The effects of global warming to high latitudinal region are more severe than the other ecosystems which were formed under the low temperature. Furthermore, in Russia, there are fire events continuously along with recent economic development. However, wide area and low accessibility of forest in Russia are main limitations for obtaining regularly taken ground-truth data. To overcome those limitations, this study used satellite-based dry condition data estimated by Keetch-Byram Drought Index (KBDI). The objective of this study is to analyze relationships between KBDI and CO_2 flux from fire events in Far East Russia from 2007 to 2018 using satellite-based meteorological and vegetation factors. For the calculation of KBDI, land surface temperature from MTSAT, NDVI from MODIS, and precipitation from GSMaP were used. MOD14 hotspot data was combined with fire radiative power (FRP) for estimating CO_2 emissions from detected fire event. As the result, fire emissions are clearly related with KBDI. In summer, the increase of fire events are highly correlated with land surface dryness within all seasons. In terms of the effect of land cover types, croplands showed different pattern of fire occurrence with other land cover types for examples savannas and forests. From these results, satellite-based KBDI can be an index of CO_2 emission from forest ecosystems in Far East Russia. For future task, not only the precipitation and LST, but also the snow-thawing cycle in meteorological factor of KBDI have to be considered to improve KBDI in cold climate regions.

R-5

RS-driven GPP model from eddy covariance flux data

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The assessment of vegetation gross primary productivity (GPP) is of great importance for terrestrial ecosystem carbon budgets and climate change. Eddy covariance (EC) technique provides long-term continuous and frequent observations of CO_2 flux at the ecosystem level. Remote sensing techniques conduct consistent and systematic monitoring of vegetation structure and function at regional and site levels. How to effectively relate CO_2 flux observations with remote sensing techniques at site level and ultimately to implement repetitive observations of CO_2 flux over extensive spatial areas are becoming critical challenges for assessing terrestrial ecosystem carbon budgets and monitoring ecosystem dynamical processes. The key for addressing these questions lies in the development of remote sensing-based ecosystem process models at broad spatial scales that can be effectively and quantitatively parameterized and validated by CO_2 fluxes at site level.

Among all the predictive methods of GPP, the light use efficiency (LUE) model has the most potential to adequately address the spatial and temporal dynamics of GPP because of its theoretical basis and practicality. However, accurate estimations of the fraction of absorbed photosynthetically active radiation (fAPAR) and the light use efficiency (LUE) are two large sources of model uncertainties for LUE models. Previous studies showed that the sensitivity of the normalized difference vegetation index (NDVI) to variations in fAPAR usually decreases when fAPAR exceeds 0.7 for moderate- to-high vegetation density and was also influenced by plant phenology; LUE was not a prescribed constant during the whole growing season and was not only related to the absorbed photosynthetically active radiation (APAR) by green vegetation but also affected by soil water content (SWC), nutrient conditions, ratio of direct to diffuse radiation, canopy age and site history. Thus, studies on how to improve the accuracy of remote estimation models for fAPAR and LUE were especially essential.

This study aimed to reveal the empirical relationship between NDVI and fAPAR and the light use efficiency (LUE) via vegetation canopy chlorophyll content (CCC_{canopy}) based on in situ measurements of spectral reflectance, biophysical characteristics, ecosystem CO_2 fluxes and micrometeorological factors over a maize canopy in Northeast China as a case study. The results showed that the fAPAR increased rapidly with the day of year during the vegetative stage, it remained relatively stable at the stage of reproduction, and finally decreased slowly during the senescence stage. In addition, $fAPAR_{green}$ [= fAPAR × (green LAI/green LAI_{max})] showed clearer seasonal trends than fAPAR. The NDVI, red-edge NDVI, wide dynamic range vegetation index(WDRVI), red-edge position (REP) and REP with sentinel-2 bands derived from hyperspectral remote sensing data were all significantly positively related to $fAPAR_{green}$ during the entire growing season. In a comparison of the predictive performance of VIs for the whole growing season, REP was the most appropriate spectral index, and can be recommended for monitoring seasonal dynamics of fAPAR in a maize canopy. Among the common chlorophyll-related vegetation indices (VIs), CCC_{canopy} had the most obviously exponential relationships with REP(R^2=0.97, p<0.001) and NDVI (R^2=0.91, p<0.001). In a comparison of the indicating performances of NDVI, ratio vegetation index (RVI), WDRVI, and 2-band enhanced vegetation index (EVI2) when estimating CCC_{canopy} using all of the possible combinations of two separate wavelengths in the range 400－1300 nm, EVI2 [1214, 1259] and EVI2 [726, 1248] were better indicators, with R^2 values of 0.92 and 0.90 (p <0.001). Remotely monitoring LUE through estimating CCC_{canopy} derived from field spectrometry data provided accurate prediction of midday GPP in a rainfed maize agroecosystem (R^2=0.95, p<0.001). This study provides a new paradigm for monitoring vegetation GPP based on the combination of LUE models with plant physiological properties.

Key words: fAPAR, canopy chlorophyll content, eddy covariance, hyperspectral remote sensing, light use efficiency, spectral vegetation indices, maize canopy

R-6

Temporal dynamics of satellite-derived photochemical reflectance index (PRI) and solar-induced fluorescence (SIF) in climate-changing Mongolia

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In recent years, optical data observed by Earth observation satellites enables us to obtain two indices, which are directly linked to light use efficiency (LUE) of terrestrial vegetation; photochemical reflectance index (PRI) and solar-induced fluorescence (SIF). In a photosynthetic process, a part of absorbed light energy is consumed as heat dissipation and some other part is emitted as fluorescence. PRI correlates with the state of the xanthophyll cycle which is related to heat dissipation [Gamon et al. 1992] and SIF is the fluorescence observed under solar-radiation [Frankenberg et al., 2011; Joiner et al. 2011]. Thus, both PRI and SIF may give us complementary information, however, it is difficult to use them simultaneously. The first problem is the difference between the viewed subjects in a canopy. Because PRI is determined by the change in surface reflectance whereas SIF is a radiance emitted from leaves or canopies, PRI reflects the stress conditions of the leaves at canopy surface but SIF correlates more with whole canopy LUE (or GPP). The time scales of these indices also make it difficult to use. In a long time scale, such as seasonal change, the effect of the ratio of chlorophyll and carotenoids on PRI is larger than that of the status of xanthophyll cycle [Gamon & Berry, 2011]. On the other hand, because satellite-SIF has relatively low signal-to-noise ratio and it must be averaged over several weeks or a month in general. Therefore, to understand light energy partitioning in a single leaf, the simple comparison between PRI and SIF is no meaning. In this study, we aimed to quantify and solve these problems and develop the method to analyze light energy usage in vegetation canopy by using satellite-PRI and SIF.

We examined temporal changes in satellite-PRI and SIF in two subregions in and around Mongolia; one is a taiga subregion, Selenge-Orhon river basin (104°E–108°E and 48°N–51°N) and the other is a steppe subregion, the center of Mongolian-Manchurian grassland in Dornod province (110°E–120°E and 46°N–51°N). Mongolia is under rapid warming and experienced historic drought events in the late 1990s and 2000s [Hessl et al. 2018]. We hypothesized that (1) the difference of root depth between grassland and forest should affect the responses of PRI and/or SIF to drought in each subregion, and (2) the differences of canopy structure between grassland and forest should make the different responses of PRI and SIF to photosynthetic active radiation (PAR). To test these hypotheses and reveal the temporal changes in PRI and SIF related to other environmental changes, we analyzed satellite data and metrological data from 2009 to 2018. PRI was obtained from MODIS surface reflectance products [Vermote and Wolfe, 2015] for both morning (Terra) and afternoon (Aqua). We used MODIS band 1 reflectance (620–670 nm) as the reference of PRI instead of the general 570 nm reflectance, according to recent studies [e.g. Gamon et al., 2016; Middleton et al., 2016]. SIF was retrieved from GOSAT, according to Frankenberg et al. (2011). To understand the consequence between these optical indices and environmental conditions, we examined the relationship between PRI/SIF and land surface temperature and surface skin soil moisture.

F-1

Experiences Measuring Methane Fluxes across a Meso-Network of Restored Fresh Water Wetlands, Rice and Irrigated Pastures in California, and Beyond

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Society is looking for Natural Carbon Solutions to offset carbon emissions from fossil fuel combustion. Restoration of wetlands or planting rice are logical options since flooding can preserve large carbon stores in the soil, as peat, for geological time periods. Unfortunately, we are finding ‘there is no free lunch’. Flooding also leads to ideal conditions for producing methane, a greenhouse gas many times stronger than CO_2 on the scale of human life time.

The Berkeley Biometeorology lab has been measuring methane fluxes across a network of sites in the Sacrament-San Joaquin Delta of California year-round since 2007. Due to our long growing season, ample sunshine, and high productivity, we are observing some of the largest amounts of methane emitted world-wide. But the story gets more complicated as we add more sites and make longer measurements. Year to year variation in methane fluxes is high and can be due to phenology, salinity, change in soil chemistry, amount of legacy dead biomass and water management. Using mutual information theory, we studied how such factors as photosynthesis, water and soil temperature, evaporation, salinity and water table modulate methane fluxes. We find, for example, that methane fluxes on monthly time scales is closely related to photosynthesis when water is fresh and amount of legacy biomass is low. When water is more brackish, as during our droughts, temperature becomes dominant. Across sites we see an orthogonal response between methane and carbon fluxes. Sites with the greatest annual methane emissions are those with the lowest annual net carbon exchange.

How do our results relate to elsewhere? At this writing, the global methane flux community is building a synthesis database, like FLUXNET. We show some preliminary synthesis results that is emerging from this analysis.

F-2

Temporal variation of methane fluxes and its biophysical drivers in a subtropical mangrove wetland

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Coastal mangrove wetlands can sustain a high carbon sequestration rate. However, mangroves are also potentially ideal hotbeds for methane (CH_4), a powerful biogenic greenhouse gas, owing to the presence of active root exudation and carbon-rich sediments. Given the favorable meteorological characteristics (high temperature and abundant rainfall) in the tropics and subtropics for methanogenesis, CH_4 emissions can potentially offset part of the climatic impacts of a high net ecosystem production (NEP) in mangroves. Ecologists often use the upscaled CH_4 results obtained from either chamber measurements or empirical *k* models to estimate ecosystem-scale flux in wetland ecosystems. Yet, the complexity of biogeochemical processes in coastal wetlands and a paucity of continuous hydrological measurements reduce our confidence in the process-based flux estimates. Over the past two decades, the steady development of the eddy covariance (EC) approach has helped us understand the temporal variation of ecosystem-scale CH_4 fluxes and its biophysical drivers for different types of wetlands, but no long-term results have been reported for mangroves.

In this study, we analyzed three years of CH_4 data collected by an EC system in a subtropical estuarine mangrove wetland dominated by *Kandelia obovata* in Hong Kong SAR, China. Diurnal pattern of CH_4 fluxes displayed two peaks right before and after mid-noon, which coincided with the diurnal pattern of temperature and plant productivity. High temperature and low salinity resulted in a CH_4 peak emission that reached 0.1 gC-CH_4 m^{-2} day^{-1} during the summertime, while the wintertime CH_4 fluxes were negligible. The annual budgets of CH_4 fluxes were estimated to be 11.4 ± 0.6, 11.8 ± 0.6 and 11.8 ± 0.8 gC-CH_4 m^{-2} $year^{-1}$ for 2016, 2017 and 2018, respectively. Although these values were comparatively small relative to the estimates from freshwater wetlands, the positive radiative forcing caused by CH_4 emission can offset the negative one caused by NEP by 144% and 67% using the 20-year and 100-year sustained-flux global warming potentials (SGWPs), respectively, which were much larger than the previous estimate of 20% on a global scale.

We used a combination of wavelet decomposition and mutual information to identify the scale-emergent and non-linear interactions between CH_4 fluxes and their biophysical drivers. At the hourly and diel scales, temperature and plant-related activities including evapotranspiration, net ecosystem CO_2 exchange (NEE) and gross primary productivity (GPP) shared most information with CH_4 fluxes through synchronous processes. At the multiday scale, CH_4 fluxes were dominantly coupled to hydrological variables including tidal water temperature, salinity and dissolved oxygen, and the dominant interactions were asynchronous. Wavelet-information results highlighted the importance of long-term monitoring of hydrology in gaining a better prediction of CH_4 fluxes in coastal wetlands over time.

F-3

Greenhouse gas fluxes characteristics in small aquaculture ponds in Yangzi river delta of China

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As a component of inland small waters, freshwater aquaculture ponds are important anthropogenic greenhouse gases sources. Aquaculture production of China is the largest in the whole world. In China, the area of aquaculture ponds accounts for 47.12% of the freshwater aquaculture area. The area of aquaculture ponds in Yangzi river delta is the largest. However, the greenhouse gas fluxes dynamics is uncertain in small aquaculture ponds in Yangzi river delta. In this study, combined eddy covariance method with floating dynamic chamber and transfer coefficient methods, CO_2, CH_4, and N_2O flux dynamics and their impact factors are identified in small aquaculture ponds located in Guandu (31° 58′ N, 118° 15′E), Anhui Province, China. The results showed that CO_2, CH_4, and N_2O fluxes were the highest in summer and the lowest in winter. The small aquaculture ponds were CO_2 neutral. The annual mean CO_2 flux was -0.0042 ± 0.048 mgCO_2 $m^{-2}s^{-1}$. The small aquaculture ponds were CH_4 and N_2O source. The annual mean CH_4 flux and N_2O flux were 4.49 ± 4.95 µg CH_4 $m^{-2}s^{-1}$ and 0.01µg N_2O m^{-2} s^{-1}, respectively. The CH_4 emission was higher than that in the aquaculture zone of large lake. However, the N_2O emission was lower than that in paddy field and large shallow lake (Lake Taihu) in the same climate zone. Water temperature was a main meteorological factor that controlled the seasonal variations of the three greenhouse gases flux. Moreover, anthropogenic management is an important factor that impact the three greenhouse gases emissions from the small aquaculture ponds. Currently, the area of aquaculture ponds increases rapidly in China. Discerning the key environmental and anthropogenic factors affecting CO_2, CH_4, and N_2O fluxes is a basis for adopting optimal management to mitigate the three greenhouse gases emissions from the aquaculture ponds.

F-4

Net ecosystem exchange of CO_2 from two land-uses on tropical peatlands in Sarawak, Malaysia

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Indonesian and Malaysian oil palm plantations expansion have been intensifying in the recent decades. Tropical peat swamp forests are also not excluded from being utilized for high scale oil palm plantation, owing to its high accessibility. Drainage is the foremost prerequisite for peatlands conversion into plantation, and often associated with environmental issue especially carbon dioxide (CO_2) emissions through accelerated peat decomposition. In addition, changes in aboveground biomass can also have a substantial effect on the CO_2 exchange dynamics of the ecosystems. However, direct measurement using eddy covariance (EC) technique to quantify such changes is still non-existence.

This study monitored eddy CO_2 flux above a tropical peat swamp forest and an oil palm plantation on peat in Sarawak, Malaysia since 2011 using EC technique. The two sites were about 100km apart from each other. The main objective of the study is to understand the changes in CO_2 exchange dynamic following conversion by comparing two sites with different land-uses. Forest site was used to represents the condition before conversion and the oil palm plantation represents the condition after conversion.

In the first 4 years of the study, the forest was a moderate CO_2 sink (NEE of -136 ± 51 g C m^{-2} yr^{-1}), but the plantation a stable CO_2 source (NEE of 994 ± 158 g C m^{-2} yr^{-1}). The large NEE following conversion was caused by reduction in gross primary production (GPP) (3682 ± 149 g C m^{-2} yr^{-1} vs. 2529 ± 125 g C m^{-2} yr^{-1}) attributable to lower leaf area index and large ecosystem respiration (RE) (3523 ± 152 g C m^{-2} yr^{-1}) similar to that of the peat swamp forest (3546 ± 149 g C m^{-2} yr^{-1}). Decomposition of coarse woody debris (CWD) presents on the ground after land preparation was the contributor to the large positive NEE as it was approximated at about 950 g C m^{-2} yr^{-1} on average, which is almost equivalent to NEE in the oil palm plantation. Therefore, NEE can approach zero without the CWD even if the peat was drained for plantation.

F-5

Radiation controls the interannual variability of evaporation of a subtropical lake

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Does lake evaporation increase or decrease under the scenario of climate warming? This paper aims to identify the controlling mechanism of lake evaporation based on the eddy covariance measurement over more than 7 years combining a diagnostic analysis based on surface energy balance principle. The results indicated that lake evaporation was enhanced mainly by increasing energy inputs including solar radiation and incoming longwave radiation, and weakened by surface feedback through outgoing longwave radiation. The incoming longwave radiation was positively correlated with cloud cover. Bowen ratio and surface albedo had slight effect on the change of lake evaporation. The annual lake evaporation can be predicted by the Priestly-Taylor model using a bigger coefficient of 1.39, which indicates the effect of advection or entrainment on lake evaporation should be considered.

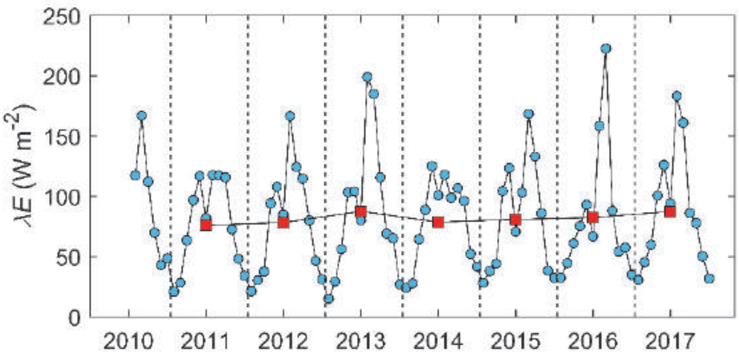

Figure 1. Time series of monthly and annual λE at Lake Taihu. Blue circles and red squares denote monthly and annual means, respectively.

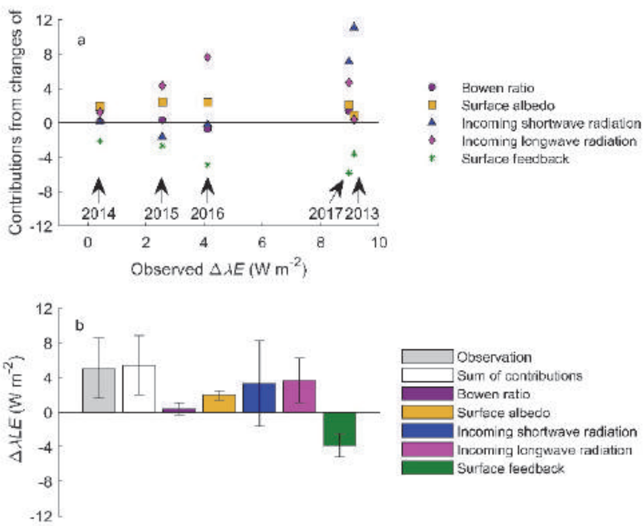

Figure 2. Attribution of the annual lake evaporation change $\Delta\lambda E$. a: results for individual years from 2013 to 2017. b: multi-year means. Error bars are ± one standard deviation.

F-6

Attribute parameter characterized the seasonal variation of gross primary productivity (α_{GPP}): Spatiotemporal variation and influencing factors

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The seasonal dynamic of gross primary productivity (GPP) has influences on the annual GPP (AGPP) of the terrestrial ecosystem. However, the spatiotemporal variation of the seasonal dynamic of GPP and its effects on spatial and temporal variations of AGPP are still poorly addressed. In this study, we developed a parameter, α_{GPP}, defined as the ratio of mean daily GPP (GPP_{mean}) to the maximum daily GPP (GPP_{max}) during the growing season, to analyze the seasonal dynamic of GPP based on Weibull function. The α_{GPP} was a comprehensive parameter characterizing the shape, scale, and location of the seasonal dynamic curve of GPP. We calculated α_{GPP} based on the data of GPP for 942 site-years from 115 flux sites in the Northern Hemisphere, and analyzed the spatiotemporal variation and influencing factors of the α_{GPP}. We found that the α_{GPP} of terrestrial ecosystems in the Northern Hemisphere ranged from 0.47 to 0.85, with an average of 0.62±0.06. The α_{GPP} varied significantly both among different climatic zones and different ecosystem types. The α_{GPP} was stable on the interannual scale, while decreased as latitude increased, which was consistent across different ecosystem types. The spatial pattern of the seasonal dynamic of astronomical radiation was the dominating factor of the spatial pattern of α_{GPP}, that was, the spatial pattern of the seasonal dynamic of astronomical radiation determined that of the seasonal dynamic of GPP by controlling that of seasonal dynamics of total radiation and temperature. In addition, we assessed the spatial variation of AGPP preliminarily based on α_{GPP} and other seasonal dynamic parameters of GPP, indicating that the understanding of the spatiotemporal variation of α_{GPP} could provide a new approach for studying the spatial and temporal variations of AGPP and estimating AGPP based on the seasonal dynamic of GPP.

T-1

Applicability of a closed-path gas analyzer based on quantum cascade laser (QCL) spectrometers for EC flux measurements of N_2O and NO over a cropland

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Croplands are important sources of atmospheric nitrous oxide (N_2O) and nitric oxide (NO) due to intensive use of nitrogen fertilizers. N_2O is a greenhouse gas, while NO is an important precursor of air pollutants, which is reactive and participates in many atmospheric chemistry reactions. The eddy covariance (EC) method has been widely used for measuring energy and mass exchanges between biosphere and atmosphere. However, there are only a limited number of studies using the EC method for flux measurements of N_2O and NO. We also found that all the existing EC studies on NO are based on closed-path chemiluminescent analyzers for NO detection. However, this type of instruments may have limitation in solving high frequency turbulence, as they usually have a true instrumental response time of up to 0.2 s.

In this study, a closed-path gas analyzer based on two quantum cascade laser (QCL) spectrometers is used for simultaneous flux measurements of N_2O and NO over a cropland using the EC method. The purpose is to evaluate the applicability and performance of this closed-path QCL analyzer in measuring the turbulent fluxes of N_2O and NO. It should be noted that the observed NO fluxes represent the turbulent fluxes at the sensor height, rather than the soil surface emissions. The systematic errors caused by chemical reaction loss of NO under the sensor height was not discussed in this study.

The field measurements were conducted for two months over a subtropical vegetable field in central China, with nitrogen fertilization having already commenced two months before the measurement started. The performance of the QCL analyzer was stable during the whole measurement period, showing an average precision of 0.263 and 0.338 ppbv for 10 Hz N_2O and NO concentration measurements, respectively. The corresponding flux detection limit was 8.7 μg N m^{-2} h^{-1} for N_2O and 5.6 μg N m^{-2} h^{-1} for NO (95% confidence interval).

The measured N_2O fluxes ranged from 7.3 to 402.7 μg N m^{-2} h^{-1} (median: 68.3 μg N m^{-2} h^{-1}), meaning that the EC system could detect almost all the half-hourly N_2O fluxes with high confidence. The NO turbulent fluxes were much lower in magnitude, ranging from −5.4 to 60.2 μg N m^{-2} h^{-1} (median: 3.5 μg N m^{-2} h^{-1}), with an average random error of 290%. The EC system could only resolve 37% of the half-hourly fluxes with high confidence. However, it could be still qualified for measuring NO turbulent fluxes over common croplands if flux estimates at daily or longer timescales are of interest, because both flux detection limit and random error would become even lower. The systematic errors caused by spectral attenuation was estimated at −8% on average in both N_2O and NO fluxes. Uncertainties in lag time determination contributed another 3% systematic underestimation in the NO turbulent fluxes.

This study shows that the closed-path dual-QCL analyzer could be an effective alternative for EC measurements of N_2O and NO fluxes with the advantages of (i) stable performance and high precision, (ii) fast response and capacity of measuring high frequency variation of turbulence, and (iii) easy operation under field conditions due to reduced need for site calibration. However, the observed NO turbulent fluxes still underestimated the soil NO emissions due to chemical reaction loss of NO under the sensor height. Further studies are necessary to address this systematic error.

T-2

An open-path QCL-based sensor for fast and 0.5 ppbv sensitivity measurements of atmospheric ammonia

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Ammonia (NH_3) emissions from farmlands and livestock are attracting more and more attention. There is an urgent need for ground-based instruments that can acquire the spatial and temporal variability in NH_3 concentrations and emissions, particularly in field environments where power and shelter are not readily available. However, accurate measurements of atmospheric NH_3 is of great challenges due to its reactive nature. Most of the available NH_3 sensors are subject to drawbacks, such as slow response time, limited precision, intensive maintenance, or high power consumption due to use of the closed-path tube, optics and vacuum pump.

We have developed an open-path sensor for fast (10 Hz) and sub-ppbv sensitivity measurements of atmospheric NH_3 concentration (Fig. 1). The sensor is based on second-harmonic (2f) wavelength modulated laser absorption spectroscopy technique (WM-LAS), which employs a distributed-feedback semiconductor quantum cascade laser (DFB-QCL) and a HgCdTe (MCT) photodetector, both cooled by a thermoelectric cooler. An open-path Herriott cell configuration with 0.5 m physical path and 46 m optical path-length is used for selective and sensitive detection of the mid-infrared absorption transition of NH_3 at 9.06 μm [1]. The sensor has a precision (1σ noise level) of 0.53 ppbv and 0.15 ppbv at sampling frequency of 10 Hz and 1 Hz, respectively (Fig. 2). The entire NH_3 sensor has a weight of ~5 kg and dimensions of 84 cm (length) and 20 cm (diameter). It can be powered by rechargeable lithium batteries, with a total power consumption of as low as 50 W.

The NH_3 sensor shows good stability under a wide range of environmental conditions, as well as good performance in vibration resistance. It can be used in ground-based or vehicle-based (Fig. 3, integrating with a GPS module) measurements of atmospheric NH_3 concentration. Furthermore, with the good performance in terms of response time and precision, this sensor is an ideal tool for NH_3 flux measurements based on the eddy covariance technique [2]. Flux studies which is able to accurately quantify the net exchange flux of atmospheric ammonia will be presented during the workshop.

Fig. 1. A photo of the NH_3 sensor.

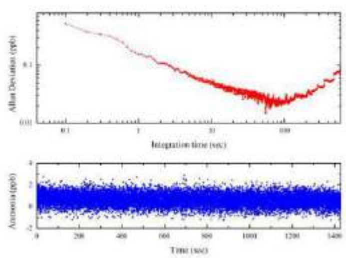

Fig. 2. An Allan deviation plot showing stability and precision of the NH_3 sensor.

Fig. 3. Spatial variation of NH_3 concentration near a pig farm.

References:

[1] Miller, D. J., Sun, K., Tao, L., and Zondlo, M. A.: Open-path, quantum cascade-laser-based sensor for high-resolution atmospheric ammonia measurements, Atmos. Meas. Tech., 7, 81–93,2014.
[2] McDermitt, D., Burba, G., Xu, L., Anderson, T., Komissarov, A.,Riensche, B., Schedlbauer, J., Starr, G., Zona, D., Oechel, W.,Oberbauer, S., and Hastings, S.: A new low-power, open-path instrument for measuring methane flux by eddy covariance, Appl.Phys. B, 102, 391–405, 2011.

T-3

A mass spectrometric observation of multiple soil gas fluxes with a portable ultra-high resolution mass spectrometer (MULTUM) coupled with an automatic chamber

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Mass spectrometric (MS) chemical analysis in general has a large advantage in higher sensitivity and universal detection capability, and has been thus widely used for trace analysis of various chemical compounds. But application of MS techniques for simultaneous measurement of greenhouse gases (GHGs), such as O_2, CO_2, N_2O, and CH_4, has been quite difficult since N_2O and CO_2, two important GHGs, share quite similar mass (44.001 u and 43.989 u, respectively) and their ions are quite difficult to be distinguished as independent ion peaks with an ordinary mass spectrometer like quadruple mass spectrometer. In order to independently detect N_2O^+ and CO_2^+ by mass spectrometry, mass resolution larger than 8000 is necessary, which is in the range of so-called high- or ultrahigh-resolution mass spectrometers and only laboratory-based mass spectrometers could offer.

It is until recent when direct and simultaneous mass spectrometric *field* measurement of multiple GHGs becomes feasible (Anan et al., 2014), after a portable ultrahigh-resolution multi-turn time-of-flight mass spectrometer (MULTUM) was introduced, which is about desktop PC in size and has adequate higher mass resolution (30000-50000) for the direct mass spectrometric separation of natural gas mixture (Shinma et al, 2010). Although the MULTUM could well resolve N_2O^+ and CO_2^+ ion peaks, it was still technically hard to simultaneously measure the two gas species with different concentrations by more than several-orders of magnitudes due to the limited dynamic range of ion detectors. Another problem is ion suppression effect in electron ionization ion source in which major gases restrict ionization of trace gases and result in much lower sensitivity for trace gases. Even with the MULTUM, these inherent restrictions in MS technique had to be mitigated for simultaneous atmospheric gas measurement of O_2, CO_2, CH_4, and N_2O, which spans by 6 orders of magnitudes.

In this work, we developed a field deployable MS-based multi-gas flux measurement system utilizing a portable high resolution mass spectrometer (MULTUM) with an automated chamber (Figure 1). To overcome the inherent restrictions in MS technique, sample atmospheric air was briefly separated into each component with a short gas separation column and a hybrid ion detection technique was utilized for wider dynamic range to enable qualitative and simultaneous measurements of multiple gases with concentrations differed by 6 orders of magnitudes. The system simultaneously observed CO_2, N_2O, CH_4, and O_2 every 2.5 min. For flux measurement, 8 consecutive gas measurements were carried out with the chamber closed for 20 min every hour to obtain hourly soil-atmosphere gas fluxes. A field study was conducted in a soybean field at the Ehime University farm (Ehime, Japan) in September, 2018 (Figure 1). The temporal variation of N_2O fluxes was mostly below 300 µg N m^{-2} h^{-1} and showed a dependence on soil moisture. After a precipitation, a rapid and significant increase in N_2O flux to 700 µg N m^{-2} h^{-1} was observed although no significant variation was observed in CO_2 flux.

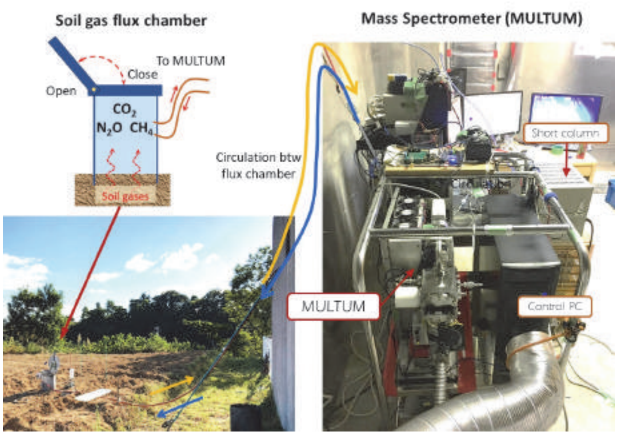

Figure 1. Schematic view of field observation in a soybean field at Ehime University farm. (Left) an automatic soil chamber, (Right) MULTUM mass spectrometer system.

The observation results clearly show that the continuous hourly multiple gas flux observation is quite informative and can provide much deeper insight into soil microbiological ecosystems and physicochemical processes underlying mechanisms of GHGs emissions.

Observation of vertical profiles of NO, O_3, and VOCs to estimate their source and sink distributions by inverse modelling in a Japanese larch forest

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The emission and absorption of trace gases at the biosphere affects to atmospheric chemistry, and thus it makes influence with potential indirect effects on carbon cycle and climate (Ollinger et al., 2002). However the detailed dynamics of these species within a canopy are not well known. The concentration profiles of O_3, NO and volatile organic compounds (VOC) were measured in a larch forest and discussed their sink or source distributions within the canopy estimated by inverse models.

The height of the observation tower is around 30 m. O_3 and NO concentrations were measured by an ultraviolet absorption O_3 analyser and a chemiluminescencence NO_x analyzer, respectively. The air for O_3 and NO was sampled every 220 seconds from four heights, above the canopy (28 m), near crown (16 m), at trunk space (10 m), and just above the ground (2 m). VOC were sampled by gas sampling tubes every 3 hours from 9:00 to 18:00 at the height of 27 m, 22 m, 16 m, 10 m, and 2 m. Micrometeorological data, such as wind speed, wind direction, radiation, precipitation, and temperature, were also observed. Eulerian and Lagrangian inverse multilayer models (Ueyama et al., 2014) were applied for estimating fluxes and identifying the sink and source distributions of these gases within the forest canopy.

Daytime-averaged simulated sink or source distributions by the models and the O_3 and NO concentration profiles are shown in Fig. 1. The distinct trace gas sinks or sources were explained by absorption, deposition, and emission by the canopy leaves, floor plants, and soil. Higher O_3 deposition and absorption were estimated at the forest floor compared to those in the canopy layer, which suggests that floor plants were important in understanding trace gases dynamics in the forest. The NO sink at the trunk space was mainly caused by a chemical loss reaction with O_3. The inverse models estimated the sinks or sources of the BVOCs and their oxidised products, which could be explained by deposition, absorption, and emission by leaves of the canopy and understory. This study showed the possibility to apply the model inversion for estimating the vertical O_3, NO and VOC sink and source distributions within a forest canopy.

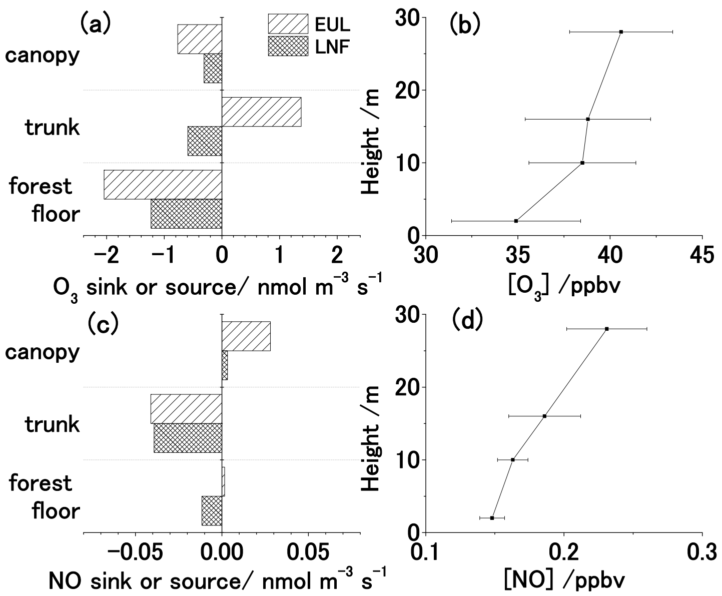

Fig. 1. Daytime-averaged simulated sink or source distribution of (a) O_3 and (c) NO using the Eulerian (EUL) and Lagrangian (LNF) models and concentration profiles for (b) O_3 and (d) NO.

T-5

Biogenic volatile organic compound emission from Tokyo urban area, Japan

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Biogenic volatile organic compound (biogenic VOC or BVOC) emissions from urban trees are pointed out as one of the possible causes of regional tropospheric ozone formation. However, the BVOC emission inventory in urban areas such as Tokyo remains uncertain, and must be determined in order to fully clarify the role of those reactive VOCs to the elevated ozone concentration occurring in this megacity. In this study, we estimated an annual BVOC emission from the entire Tokyo urban area (the special wards of Tokyo).

Leaf BVOC emission rate measurement: We measured the BVOC emission rate (i.e. emission per unit leaf area and time; nmol m^{-2} s^{-1}) from the 20 most dominant street lining tree species in the Tokyo special wards. This was done by two methods, namely branch-enclosure method and leaf-cuvette method. The BVOC from leaf was immediately trapped in an absorbent tube and analyzed in the laboratory by GC-MS using thermal desorption technique. The measurements were conducted in spring, summer, autumn, and winter to test a seasonal variability in their BVOC emission rate.

Tree canopy leaf area estimation: We estimated a seasonal tree leaf area in the Tokyo special wards using WorldView-2/3 satellite imagery acquired during different tree phenology periods (leaf-on and leaf-off season). First, the tree canopy was isolated from non-tree land cover by pixel-based analysis. Next, we used field observation data of urban tree leaf area index (LAI) to directly map tree leaf area over the entire Tokyo special wards. Based on the number of tree species planted in the Tokyo special wards, we estimated the total leaf area of each tree species for the both phenology seasons.

Total BVOC emission estimation from Tokyo special wards: Using the aforementioned results, we estimated the total BVOC emission in 2014, 2015 and 2016. Total emissions of the tree species were calculated by multiplying their BVOC emission rates (unit leaf area and time) by the total leaf area of each tree species, respectively. We herein used the BVOC emission rate that was adjusted by temperature/light condition in Tokyo (35.962N, 139.750E) observed by Tokyo Regional Headquarters.

1. Nine in 20 species were found to emit BVOC, and their emission was temperature/light dependent.
2. We obtained their seasonal BVOC emission model, respectively, using the G93 algorism (Fig.1).
3. The total tree canopy leaf area herein was 281 km^2 in leaf-on season, and 97 km^2 in leaf-off season.
4. The calculated BVOC emission over the three years was 468 ± 47 t (mean ± SD) in spring, 2,014 ± 367 t in summer, 17 ± 3 t in autumn, and 0.3 ± 0.03 t in winter, with an annual total of 2,499 ± 416 t/yr.
5. This annual emission corresponds to 4% of the anthropogenic VOC emission from the entire Tokyo area (including the remaining "Tama" region) in 2015.
6. More than 80% of the annual BVOC emission concentrated in summer daytime, which coincides with the timing when ozone concentration elevates significantly in Tokyo.
7. Future studies should incorporate the BVOC inventory data obtained in this study into the atmospheric simulation models, in order to better understand the role of BVOC emissions as a precursor for regional ozone formation in urban area, such as Tokyo.

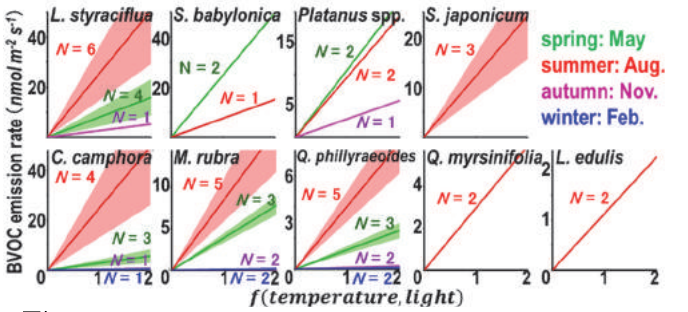

Fig. 1. Seasonal BVOC emission model (G93 algorism)

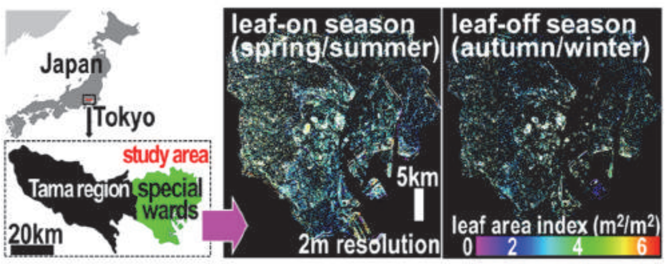

Fig.2. Seasonal map of tree leaf area in Tokyo special wards

T-6

Leaf uptake of monocyclic aromatic hydrocarbons by plants

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Plants are reported to remove several species of volatile organic compounds (VOCs) from the atmosphere. The uptake of VOCs by plants contributes directly to the purification of the atmosphere and indirectly to suppression of the generation of photochemical oxidants such as ozone. Aromatic hydrocarbons including benzene, phenol, benzyl alcohol, and benzaldehyde are ubiquitous in the atmosphere. We determined leaf uptake rate of these compounds by *Spathiphyllum clevelandii*, *Osmanthus fragrans*, *Quercus acutissima*, and *Quercus myrsinifolia* at several part per billion by volume using a measurement system consisting of a proton transfer reaction mass spectrometer (PTR-MS), infrared gas analyzer, diffusion device and two leaf enclosure bags. One bag contained the plant leaf (sample bag) and the other bag was empty (blank bag). We calculated the VOC uptake rate, net photosynthetic rate and transpiration rate from the concentration differences of VOC, CO_2, and water vapor, respectively, between sample and blank bags. The uptake rate was normalized to the fumigated concentration by dividing it by the concentration (standardized uptake rate).

Phenol, benzyl alcohol, and benzaldehyde were absorbed by plants. However benzene was not absorbed by any plants. All the plants did not uptake VOCs in the night. In the daytime, the standardized uptake rate, net photosynthetic rate, and transpiration rate increased with increasing light intensity. A positive linear relationship was observed between stomatal conductance and standardized uptake rate (Figure 1), and the slope of the regression line was different among substances and plant species. Net photosynthetic rate was not in proportion to stomatal conductance, depending on PPFD. Therefore, leaf uptake rate of VOCs is mainly controlled by stomatal conductance, but photosynthesis may be affected by other factors (PPFD, metabolism, etc.), in addition to stomatal conductance. We compared VOC uptake capacity using the slopes of the regression lines between stomatal conductance and standardized uptake rate. *Quercus myrsinifolia* tended to have lower absorption capacity compared to other plant species used in this study. We also found that *S. clevelandii* leaves exposed to phenol emitted anisole. It might be produced by methylation of phenol inside the leaf. We are now producing a model to explain plants' VOC absorption by individually describing VOC partitioning between leaf water and air and metabolic activity within leaves.

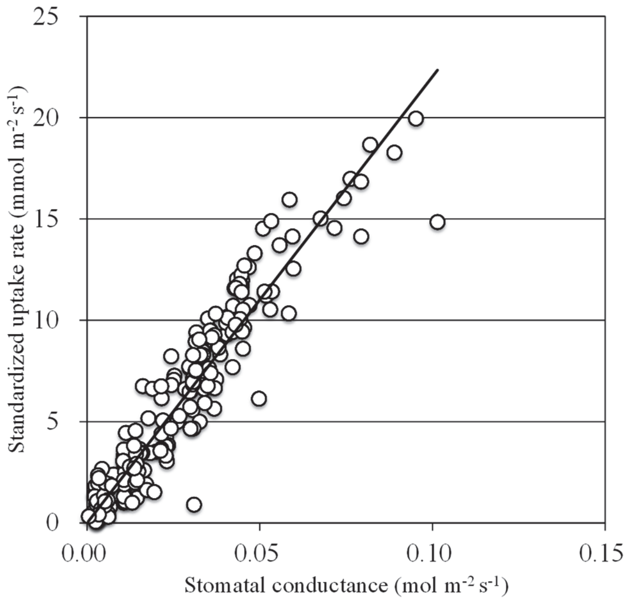

Figure 1 Relationship between stomatal conductance and standardized uptake rate

M-1

Making full use of hyperspectral data for gross primary productivity estimation with multivariate regression: mechanistic insights from observations and process-based simulations

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Hyperspectral data in the visible and near-infrared (VNIR) spectral ranges are increasingly acquired at eddy covariance sites as well as from airborne instruments and satellites. However, many researchers still reduce the information content of such data by extracting multispectral vegetation indices (VIs) or retrieving sun-induced chlorophyll fluorescence (SIF) at only one or two wavelengths. This is common practice despite the availability of appropriate multivariate methods that can take full advantage of all relevant information contained in the hyperspectral data and indications that the information in SIF in a wider spectral range can improve the estimation of gross primary productivity (GPP). Similarly to the case of SIF, xanthophyll-related spectral changes (XC) in the range of 500-570 nm are known to be related to photosynthetic light use efficiency but are typically only assessed via the multispectral photochemical reflectance index (PRI) at two wavelengths. All this suggests the potential to improve GPP estimation from hyperspectral data by including all available spectral channels when using an appropriate multivariate regression method.

Here, we applied partial least squares (PLS) regression to a continuous, half-hourly hyperspectral dataset from a rice paddy site in South Korea covering two growing seasons (years 2016 and 2017). We found that the PLS-based GPP estimation achieved very high estimation performance (R2=0.9), even when applied to the 2017 growing season of which no data was used in the model calibration. PLS clearly outperformed far-red SIF retrievals (R2=0.8) and commonly used VI-based approaches (R2<0.8). We then restricted the spectral range of the input data to test hypotheses of underlying mechanisms related to SIF and XC. We found that the NIR range of 850-900 nm had comparable performance to the full VNIR range, which excludes SIF and XC as factors underlying the estimation.

To more directly test for the contributions of SIF and XC to the GPP estimation performance, we also performed analogous PLS regression analyses on simulated hyperspectral data and GPP output from the process-based SCOPE (Soil Canopy Observation, Photochemistry and Energy fluxes) model. We found that, in contrast to the observation-based results, both SIF and XC notably improved the results. In particular, the narrow spectral range 500-570 nm including the XC signal performed as well as the full VNIR range including SIF and XC. The improvement when including SIF or XC was strongest at the diurnal time scale.

Our results clearly indicate the potential to improve GPP estimation from hyperspectral data by applying suitable multivariate regression methods. Furthermore, the process-based simulation results suggest the considerable potential of using the XC spectral range (500-570 nm) that did not receive the same amount of attention as SIF. Our findings are relevant for future large-scale GPP estimation from hyperspectral satellite data and, more generally, are expected to stimulate further research using continuous hyperspectral observations.

M-2

Modeling soil GHG emission from Changbai Mountain forest ecosystem by Forest-DNDC

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CO_2, CH_4 and N_2O, the three greenhouse gases (GHGs) have increased in the atmosphere since pre-industrial times, and this increase is the main driving cause of climate change (IPCC, 2013). Soil flux is an important path for the three GHGs exchange between soil and atmosphere. There remains uncertainty regarding the dynamic change of modeled soil GHGs flux and environmental responses, especially during the non-growing season. Production of GHGs in soils is predominantly due to the microbial processes of composition-decomposition and nitrification-denitrification. The Biochemical Model-DNDC (DeNitrification-DeComposition) (Li, 2000), which integrates the ecological process of carbon and nitrogen, has been widely used.

This study adopted a biogeochemical model (Forest-DNDC) combined with automatic flux observation system, which aimed to estimate the soil GHGs emissions in Changbai mountain forest ecosystem and to validate this model against observation data, and then to analyze the response of the GHGs emissions by the environment factors (eg. soil temperature and moisture).

The results showed that the Forest-DNDC model reproduced general patterns of environmental variables, however, simulated seasonal variation in soil temperature, snow melt processes and soil moisture partly deviated from measured variables, especially during the non-growing season. The modeled CH_4 flux was close to the field measurement and co-varied mainly with soil temperature and snowpack. The modeled soil CO_2 flux had the same seasonal trend to that of the observation along with variation in temperature, however, simulated CO_2 flux in the growing season was underestimated. The modeled N_2O flux attained a peak in summer due to the influence of temperature, which was apparently different from the observed peak of N_2O flux in the freeze-thaw period. Meanwhile, both modeled CO_2 flux and N_2O flux were dampened by rainfall events. Apart from consistent estimation of annual soil CH_4 flux, the annual accumulation of CO_2 and N_2O was underestimated. It is still necessary to further optimize model parameters and processes using long-term high-frequency observation data, especially transference of heat and water in soil and GHGs producing mechanism.

This study try to quantify the effects of environmental and biological factors on soil GHGs emissions and estimation of soil GHGs flux from the site to the region.

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M-3

Measurement and modeling of nitrous and nitric oxide emissions from a tea field in subtropical central China

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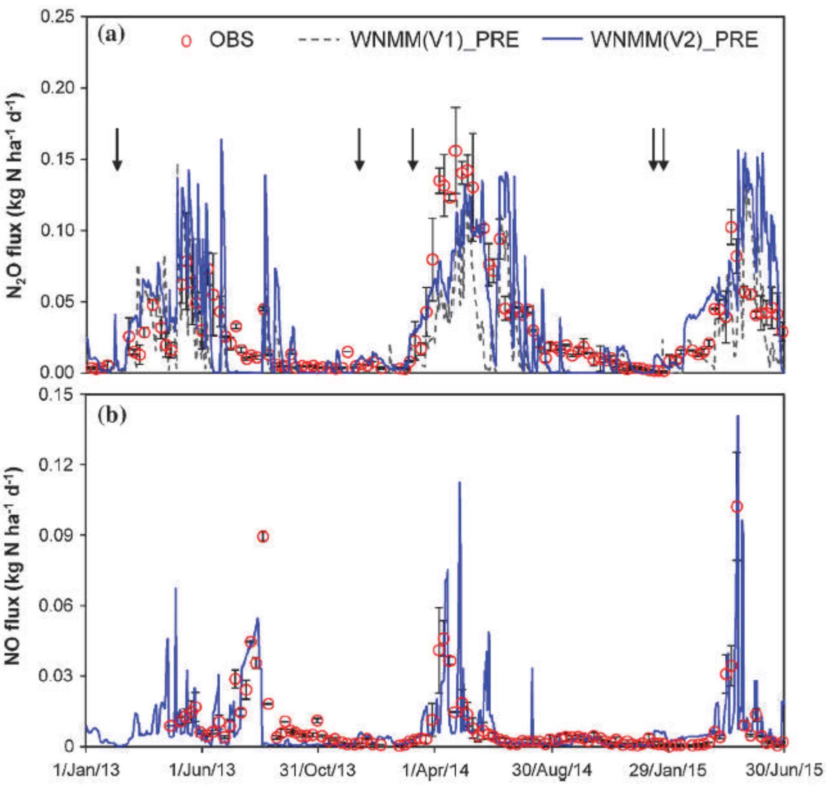
Tea fields represent an important source of nitrous oxide (N_2O) and nitric oxide (NO) emissions due to high nitrogen (N) fertilizer applications and very low soil pH. To investigate the temporal characteristics of N_2O and NO emissions, daily emissions were measured over two and a half years period using static closed-chamber/gas chromatograph and chemiluminescent measurement system in a tea field of subtropical central China. Our results revealed that N_2O and NO fluxes showed similar temporal trends, which were generally driven by temporal variations in soil temperature and soil moisture content and were also affected by fertilization events. The measured average annual N_2O and NO emissions were 10.9 and 3.3 kg N ha^{-1} yr^{-1}, respectively, highlighting the high N_2O and NO emissions from tea fields. To improve our understanding of N-cycling processes in tea ecosystems, we developed a new nitrogenous gas emission module for the water and nitrogen management model (WNMM, V2) that simulated daily N_2O and NO fluxes, in which the NO was simulated as being emitted from both nitrification and nitrite chemical decomposition. The results demonstrated that the WNMM captured the general temporal dynamics of N_2O (NSE=0.40; R^2=0.52, RMSE=0.03 kg N ha^{-1}d^{-1}, P<0.001) and NO (NSE=0.41; R^2=0.44, RMSE=0.01 kg N ha^{-1}d^{-1}, P<0.001) emissions. According to the simulation, denitrification was identified as the dominant process contributing 76.5% of the total N_2O emissions, while nitrificationand nitrite chemical decomposition accounted for 52.3% and 47.7% of the total NO emissions, respectively.



M-4

Carbon flux estimation in South Korea using eddy covariance, remote sensing, and support vector regression

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Eddy covariance measurements consistently measure the net CO_2 exchange of a whole ecosystem where observations are made and have high temporal resolution. However, these measurements only represent a site-level observation (at < 1 km^2 scales) called the flux footprint. In order to overcome this limitation, upscaling via linkage between observation data, remote sensing, and modeling methods has been used. In particular, a data-driven approach by machine learning techniques is one of the most effective upscaling way to estimate regional-scale fluxes. In this study, we estimated gross primary productivity (GPP) and net ecosystem CO_2 exchange (NEE) using flux data from 14 sites (forests: 10, non-forest: 4) in South Korea by combining with remote sensing data (i.e. MODIS) through support vector regression (SVR) from 2000 to 2018 period. Site-level evaluation of the estimated GPP and NEE from the SVR-based model shows equivalent performance compared to the previous researches (r^2 = 0.81 and 0.65 at 8 days temporal resolution, 0.61 and 0.12 for the yearly comparison, respectively). The mean estimated annual GPP and NEE of the South Korea region over the period 2000–2018 were 1375 and −366 g C year^{-1}, respectively. The mean estimated annual GPP in this study is 1370 g C m^{-2} yr^{-1} over the period 2001–2015, which was 1.25–1.4 times higher than that in the previous studies i.e., FLUXCOM, Ichii *et al.*,(2017, JGR), MODIS, and BESS. We are analyzing the potential reasons to explain such difference.

Acknowledgement This study carried out with the support of R&D Program for Forest Science Technology (Project No. 2017099A00-1719-BBB01).

Estimating high-latitude methane fluxes based on the satellite data-driven Terrestrial Carbon Flux Model

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The concentrations of atmospheric carbon dioxide (CO_2) and methane (CH_4) have been gradually increasing and have a significant influence to climate change. In this study, we used the terrestrial carbon flux, TCF, model to simulate CO_2 and CH_4 fluxes, and validated the model results with observed eddy covariance data from 15 northern ecosystem sites in high-latitude areas. The model is driven by gridded climate data and satellite data products, including surface temperatures, soil moisture, the fraction of photosynthetically active radiation from NASA MERRA reanalysis dataset and MODIS dataset.

We recalibrated the model and determined some related parameters for each classification of northern ecosystems: fen, bog, forest, tussock tundra, and wet tundra. After the calibration and validation, the simulation performance has been improved significantly at the daily and seasonal scales. We found that the simulation results is highly sensitive to the calculated decomposition rate constant for organic matter. This indicates the importance to determine the decomposition rate of different soil organic matter state which could be highly heterogeneous at each northern ecosystem and vary with different soil state and different temperatures. The final goal of this study is assessing the daily and seasonal variability in CO_2 and CH_4 fluxes across the pan Arctic/boreal ecosystems based on the satellite-driven ecosystem model, TCF Model, calibrating with the eddy covariance data.

Key words: wetland; carbon dioxide; methane; northern ecosystem.

M-6

Exploring the mechanisms controlling the seasonality and the trend in global LAI during 2001-2017

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Leaf area index (LAI) is a vital parameter in modulating the interaction between the land surface and the atmosphere and therefore is used in many terrestrial biosphere models. However, the mechanisms controlling the seasonality and the trend of LAI remain unclear. In this study, we use a regression method and the Farquhar's biochemical model to reconstruction global satellite LAI (RLAI), exploring the control mechanisms of the seasonal dynamics of global LAI and their interannual trends during 2001-2017. We found that the control mechanisms of the global seasonality LAI varied from the latitudes and seasons. Temperature, precipitation, solar radiation, and soil moisture combined can explain 98% of the seasonal dynamics of global LAI. Based on Farquhar's biochemical model, the effect of elevated CO_2 concentrations on LAI was 13.4% per 100 ppm, leading to the LAI increased was 0.05 m^2 m^{-2} from 2001 to 2017. RLAI (only climate- derived) explained 27.3% of the global LAI trend and captured 29.8% of the significant trend areas in global satellite LAI. After incorporating the CO_2 fertilization into RLAI ($RLAI_{CO_2}$), there were 68.8% of the global trend in satellite LAI can be explained, and about 63.3% of the significant trend areas were captured, which is much improved than RLAI. It is suggesting that CO_2 fertilization is the critical component in regulating global LAI trend. This study also indicates that it is feasible to use Farquhar's biochemical model to estimate the effect of CO_2 fertilization on LAI.

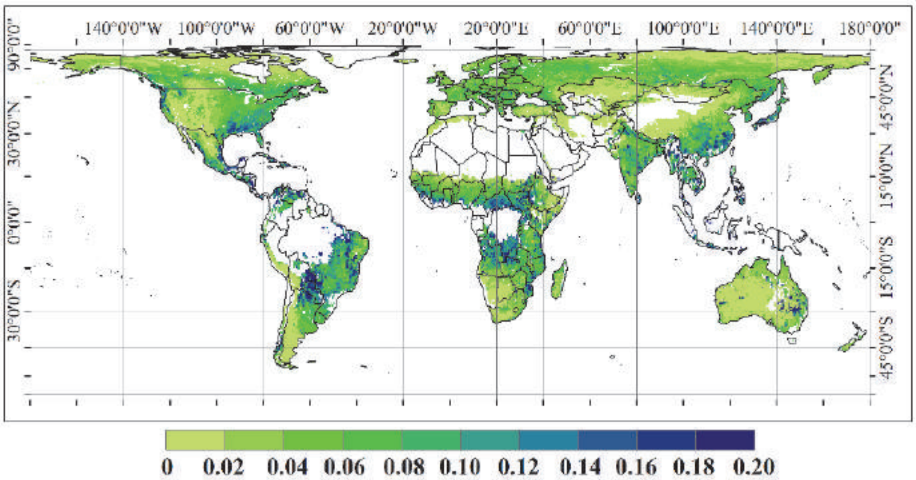

Figure. The spatial pattern of the magnitude of LAI changed due to CO_2 fertilization during 2001-2017.

E-1

Nitrogen biogeochemistry in a forest ecosystem under changing climate – Challenge and opportunity of Long-Term Ecological Research

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Nitrogen is an essential nutrient for primal productivity and carbon fluxes of ecosystem. Short-term pulse and long-term press changes of climates disturb nitrogen cycles and other key ecosystem processes through alteration of complex mechanisms. Understanding the consequences and pathway of nitrogen biogeochemical processes which provide a bundle of ecosystem functions and services under changing climate and other influences of human activities (e.g. air pollution) can help us to develop our sustainable society. Long-Term Ecological Research (LTER) Network is a powerful research platform to implement site-based observations, experiments and modellings with cross-site and/or international collaborative research to address various ecological and socio-ecological research questions including nitrogen issues (Mirtl et al. 2018; Shibata et al. 2015). I introduce a couple of research findings on nitrogen cycles of forest ecosystem in Japan LTER (JaLTER), a member of the ILTER, with 57 individual LTER sites including various ecosystems (i.e., forests, lakes, rivers, farmlands, grasslands and marines) in Japan. One of the recent in-situ experimental manipulation at a JaLTER site focused on the impact of winter climate changes on soil nitrogen dynamic in a forest ecosystem located northern Japan (Watanabe et al. 2019; Shibata 2016). The less snowpack enhanced soil freeze-thaw cycles, significantly disturbed soil microbial nitrogen transformation through the change of soil moisture regimes during the plant dormant season. The International LTER (ILTER) has been expanding with >44 member-networks and >800 individual site, as a global in situ research infrastructure (Mirtl et al. 2018). The ILTER East Asia and Pacific regional network (ILTER-EAP), a member regional network of the ILTER has unique characteristics with large variation of climatological and socio-ecological variables and has great potential to develop new research agenda on nitrogen biogeochemistry under changing climate in this region, a critical research topic relating to multiple Sustainable Development Goals (SDGs) and other key targets for multiple stakeholders. I also address a couple of key challenges and opportunities of nitrogen biogeochemical study at the regional and global LTER networks including the further possible collaboration with FLUXNET based on the on-going and planning global research programs.

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E-2

Revealing the relationship between tree diversity and ecosystem functions through long term and nationwide datasets

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In ecosystem modeling, species diversity are usually neglected or simplified into several functional types. However, diversity do matter to understand and predict ecosystem functions. In the community ecology and the related fields, the effect of biodiversity on ecosystem function has been studied intensively since 1990s especially in grassland ecosystem. On the other hand, there are fewer researches in forest ecosystems. In this presentation, I will show two examples how the tree diversity is related to forest ecosystem functions.

Firstly, forest biomass are better estimated when you include information about tree species difference. We developed generic allometric equations for aboveground biomass using large, compiled data sets of 1203 harvested trees belonging to 102 species (60 deciduous angiosperm, 32 evergreen angiosperm, and 10 evergreen gymnosperm species) from 70 boreal, temperate, and subtropical natural forests in Japan. The best generic allometric equation included explanatory variables that represent interspecific differences in wood density in addition to stem diameter, reducing error by 4% compared to the generic equations that did not include the interspecific difference. The best equation performed even better than the equation based on functional types.

Secondly, we tested whether high biodiversity may assure higher stability of ecosystem function. Simulation and experimental studies supported this hypothesis. However, there are still few studies in the natural forests. We tested this hypothesis in boreal to subtropical natural forests in Japan using long term annual tree census data (Monitoring 1000 Project by the Ministry of the Environment). Stability of tree biomass increment was not related to species diversity of the forest. However, stability was related to asynchronous growth between tree species.

These result obtained from long term and large scale datasets show the importance of considering biodiversity in understanding and predicting forest ecosystem functions.

E-3

Long-term soil warming experiment in a northern cool-temperate forest in Tomakomai, Hokkaido Japan - What was clarified or still unknown?

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The magnitude of increase in global mean air temperature is predicted to be greater at higher latitudes and will affect biogeochemical processes in forest ecosystem. Several researchers have studied the impacts of rising temperature on forest ecosystem by using long-term monitoring data of environment or data obtained from manipulation experiments. In northern Japan, we have started manipulation experiments of warming in cool-temperate forests from 2007 in Hokkaido University forests. In this talk, we introduce the long-term experiment for mature deciduous oak (*Quercus crispula* Blume) trees at Tomakomai experimental forest (TOEF; 42°40’N, 141°36’E, 80 m a.s.l.).

In the field experiment at TOEF, the temperatures of branch surface and organic soil layer (5-10 cm depth) around target trees have been warmed by using electric heating cables. As for the branch treatment, we wired the cables around 1-3-thick branches at top canopy (18-20 m height). In the case of soil treatment, we buried the cables in 5 m × 5 m area around the oak trees. We controlled the temperatures of branch and soil in treated area to < 5°C higher than the untreated branch and soil during experimental period. The warming treatments of branch and soil were conducted during 2008-2014 and 2007-2019 (ongoing), respectively.

We have evaluated both aboveground (canopy) and belowground (soil) responses to artificial warming by comparing between control and warmed treatments. As for the aboveground responses, we investigated the phenology, photosynthesis, acorn production, concentrations in nutrient and secondary metabolites, emission of volatile organic compound and herbivory rate. Clear changes induced by warming treatment were observed as the increased acorn production in first year and the reduction of leaf damage by herbivorous insect accompanied with the lowered leaf nitrogen and increased leaf phenol content. We also found that the magnitudes of leaf damage and the variation of leaf chemical traits tend to be small year by year. As for the belowground responses, dynamics of available soil nitrogen and autotrophic/heterotrophic respiration were mainly observed. Increased soil temperature reduced available inorganic nitrogen concentration in spring soil together with depletion of freeze-thawing process by warming. Both autotrophic- and heterotrophic respirations were accelerated with increasing soil temperature, but magnitude and strength of acclimation to warming environment differed between microbes and plant roots. This long-term monitoring of multiple ecosystem components indicates that (1) soil warming would affect leaf-herbivorous insect relationship via changing availability of soil nitrogen; (2) acclimation to warming environment can be occurred in both aboveground and belowground parts. Based on these findings, we discuss about the importance of long-term experiment and useful approach to evaluate resilience of forest ecosystem to changing environment.

Keywords: acclimation, belowground, tree canopy, field experiment, oak

Maximum carbon uptake rate dominates the interannual variability of global net ecosystem exchange

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Terrestrial ecosystems contribute most of the interannual variability (IAV) in atmospheric carbon dioxide (CO_2) concentrations, but processes driving the IAV of net ecosystem CO_2 exchange (NEE) remain elusive. For a predictive understanding of the global C cycle, it is imperative to identify indicators associated with ecological processes that determine the IAV of NEE. Here, we decompose the annual NEE of global terrestrial ecosystems into their phenological and physiological components, namely maximum carbon uptake (MCU) and release (MCR), the carbon uptake period (CUP), and two parameters, α and β, that describe the ratio between actual versus hypothetical maximum C sink and source, respectively. Using long-term observed NEE from 66 eddy covariance sites and global products derived from FLUXNET observations, we found that the IAV of NEE is determined predominately by MCU at the global scale, which explains 48% of the IAV of NEE on average while α, CUP, β and MCR explain 14%, 25%, 2% and 8%, respectively. These patterns differ in water-limited ecosystems *versus* temperature- and radiation-limited ecosystems; 31% of the IAV of NEE is determined by the IAV of CUP in water-limited ecosystems, and 60% of the IAV of NEE is determined by the IAV of MCU in temperature- and radiation-limited ecosystems. The LPJ model and the MsTMIP models underestimate the contribution of MCU to the IAV of NEE by about 18% on average, and overestimate the contribution of CUP by about 25%. This study provides a new perspective on the proximate causes of the IAV of NEE, which suggest that capturing the variability of MCU is critical for modeling the IAV of NEE across most of the global land surface.

Key words: Interannual variability, net ecosystem exchange, maximum carbon uptake rate, carbon uptake period, phenology, physiology

E-5

Development of long-term and multidisciplinary research and networking in forest ecosystems of Takayama site

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4 Asia Pacific Biodiversity Observation Network (APBON)
5 GEO Carbon and GHG Initiative

Challenges to understand processes and resulting dynamics of the functions in forest ecosystems have been made by various scientific disciplines/techniques such as ecology (including ecophysiology and biogeochemistry), hydrology, micrometeorology, simulation models and remote sensing. These researches focus particularly on carbon, which is one of the "common" elements of ecological processes involved in ecosystems such as photosynthesis, respiration and biomass growth, and of interaction between atmosphere and ecosystems, as carbon cycle regulates biological aspects of ecosystems and hence determines the exchange of CO_2 between the atmosphere and ecosystems. In the recent decades carbon cycle and budget have been the central theme of environmental sciences, by reflecting the on-going climate change partly due to atmospheric CO_2 rise. In order to achieve deeper understandings on the dynamics of structure and functions of forest ecosystems over time and space, investigations on (1) the detailed ecological processes in carbon cycle, (2) their interactions with the climate, (3) integrated analysis of ecological and meteorological process, and (4) observations of such structure and functions over time and space, are essential.

This paper introduces such multidisciplinary and long-term challenges at the "Takamayama site" (Figure 1, Muraoka et al. 2015), which is located on a mountainous region in central Japan. The site mainly consists of a cool-temperate deciduous broadleaf forest (TKY) and an evergreen coniferous forest (TKC) and are contributing to AsiaFlux and Japan Long-Term Ecological Research (JaLTER) networks and Phenological Eyes Network (PEN, Nasahara and Nagai 2015). The history of TKY has initiated by the long-term observation of CO_2 exchange between the atmosphere and the deciduous forest, and ecological research for the carbon cycle processes in the forest, by numbers of scientists and students from several research institutes and universities (Saigusa et al., 2005; Yamamoto and Koizumi 2005; Ohtsuka et al. 2007, 2009). Efforts have been also made to link ecology, micrometeorology, modeling and remote sensing to explore the multi-scale investigations of the ecosystems and surrounding landscape, and this initiative is called "Satellite Ecology" (Muraoka and Koizumi 2009) which was involved in a concept of cross-scale observation of ecosystems and for biodiversity-ecosystem-climate change observations in the Biodiversity Observation Network in Asia-Pacific region (AP-BON; Muraoka et al. 2013).

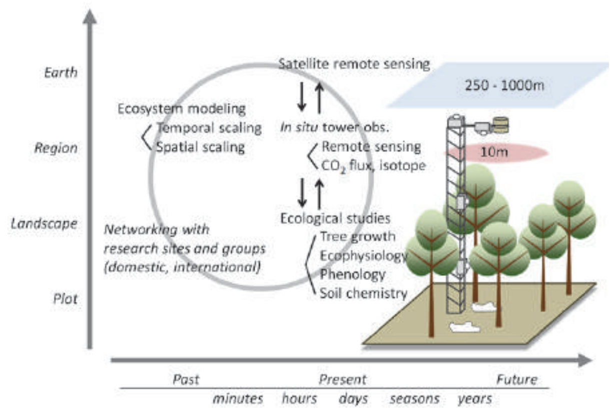

Figure 1. Multidisciplinary research and networking at the Takayama site to explore cross-scale mechanisms and consequences of forest and landscape structure and functions.

For the recent reviews of the Takayama site please refer to following paper and a special virtual issue (2015), while there are a number of publications and special issues to date.

- Muraoka H., Saitoh T.M. and Nagai S. (2015) Ecological Research 30: 197-200, DOI 10.1007/s11284-015-1251-9
- Special virtual issue by "Journal of Plant Research" and "Ecological Research": Long-term and multidisciplinary research of the forest carbon cycle at the Takayama site, Japan. https://www.springer.com/life+sciences?SGWID=0-10027-6-1485142-0

Contribution to FLUXNET and collaboration across regional networks – recent directions and developments

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FLUXNET is a success story, as demonstrated by the number of participants, the number of users and the number of scientific works based on the FLUXNET collections. However, it is now time to reflect about the future development of the FLUXNET initiative in order to increase its quality and impact in the scientific community and its contribution to the stakeholders' needs. This will open a number of challenges that must be discussed and addressed with the contribution of all the participants in order to define the next steps. In particular tow aspects are critical:

<u>Improving data quality</u>. In the last few years, the development of new methods (for measurements, processing and data storage and distribution) characterized the activities of the regional networks thanks to a progressive recognition of the need of more stable and structured research infrastructures to monitor ecosystem-atmosphere interactions (e.g. ICOS, NEON, TERN, CERN, AmeriFlux etc.). This led to the development of tools and approaches that can be (and in some cases are) shared across regional networks, improving also the data harmonization and comparability. In ICOS, in particular, procedures to evaluate the data quality have been implemented and the first results already show that improvements in our measurements are possible.

<u>Organizing FLUXNET</u>. The diversity in the FLUXNET participants and data users is the strength of the network; eddy covariance and related measurements (meteo, ancillary etc.) are used at different scales (from local to global), different time resolutions (from halfhourly to multiannual) and, more important, in a wide range of applications (ecological studies, GHG budgets, remote sensing validation, models development, parameterization and validation, etc.). The growth and heterogeneity in the range of data uses requires from the networks' side a new organization if we want to keep the FLUXNET network alive. It means, for example, more frequent releases (e.g. to link them to the satellite data collected continuously), higher level of data comparability across networks and respect of the FAIR principles, improved quality and uncertainty determination, new key variables and processes to be measured and a common promotion of the global network. To achieve these results the best solution would be a collaboration among the different networks, where all contribute to a shared and common goal of making FLUXNET more robust and sustainable.

These two aspects are linked and can be jointly addressed, with benefits for the whole FLUXNET community and for the other scientific communities that use our measurements. In the presentation, the recent developments in the data quality improvement will be presented and discussed and then linked to the overall FLUXNET development idea, with examples of how a common set of activities between AmeriFlux and the European Database allowed important step forward in the FLUXNET organization. It will be a unique opportunity to discuss these aspects with an important community like AsiaFlux and evaluate the best way to establish strong collaborations and links.

Earth system modeling and expectations for future collaboration with AsiaFlux

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An Earth system model (ESM) is a global climate model coupled with biogeochemical component, including terrestrial and marine ecosystem, models (Figure 1). Using ESMs, we can simulate the feedback between climate and biogeochemical processes, future climate change for given emission pathways and its effects to the global scale ecosystem. As an ESM is also available to estimate the allowable carbon emission for the given temperature targets, it plays an important role in discussion on future "carbon budget" (note that here this term means the cumulative allowable emission for the given temperature anomaly target, not the balance of emission and uptake).

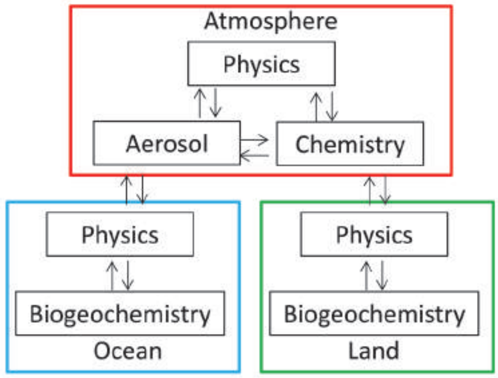

Figure 1 Structure of a typical ESM
Modified from Watanabe et al. (2011, GMD)

In this presentation we will introduce what an ESM is like, and show some examples of possible future collaboration with flux observation research.

It is obvious that we cannot develop a model without observation data, and once model is developed, we tune our model using observation data. In case of ESMs, global data products for vegetation and soil processes are often used for developing, tuning and validating ESMs, and the contribution to such datasets is fundamentally helpful to improve ESMs. In considering more direct collaboration, the major barriers between field study and global-scale Earth system modeling will be difference in spatial and temporal scales. For the former, the spatial resolution of current ESMs are around 100–300 km, which makes it difficult to directly compare the models' outputs with point-based observation data. For the latter, because an ESM run typically covers long-term (100 years or more) time scale, such long-term observation is needed for meaningful comparison. Remote sensing and off-line models could be effective tools to bridge the gap and are already attempted in collaboration with some AsiaFlux researchers. Another possible way of collaboration will be "emergent constraint", a method to constrain long-term future projection simulated by global climate models by using short-term observation results. Occasionally a clear relationship between the short- and long-term response are found for ESMs and by that relationship we can constrain the long-term sensitivity by constraining the short-term sensitivity (e.g., seasonal amplitudes or sensitivity to the El Niño-Southern Oscillation), for which point-based shorter-time scale observation can have large impact to constrain the long-term sensitivity.

L-3

Climate science and social values

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The Future Earth, a currently operating international platform of sustainability science, calls for trans-disciplinarity, meaning co-designing and co-producing science with various non-academic stakeholders in the society. The need of trans-disciplinarity is justified from three perspectives: the logic of accountability, the logic of impact and the logic of humility (van der Hel, 2016). The logic of humility, which is often overlooked, essentially means that scientists should reflect on their own perceptions and values, which may be biased in various ways, and should appreciate diverse values of various stakeholders in the society.

For example, when we observe climate debates in the society, different opinions based on different values over risk perceptions of climate change or various mitigation options can be identified. The climate issue is inevitably value-laden and climate science cannot be free from values as well. Observational research might look relatively value free, but what to measure and where to measure, for example, already involve some kind of value judgment. Also, continuous measurement needs stable fund, which leads to a situation that research might be influenced by the values of funders.

Typologies and recommendations on how scientists behave in such value-laden research environment have been discussed by social scientists (e.g., Honest Broker, Pielke, 2003). Here I present the idea of Reflective Advocacy (Asayama et al., 2017), which is characterized by transparency, anticipation, reflection, deliberation and responsiveness.

Abstracts: Poster Presentations (day 2)

P1-F1

Year-round measurements of methane and carbon dioxide fluxes in two urban landscapes

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Measurements of urban greenhouse gas emissions are important. In particular, methane (CH_4) fluxes were rarely measured in urban areas; thus its budgets and variabilities are highly uncertain. Limited studies reported that emission inventories underestimated urban CH_4 emissions. Continuous flux measurements and mobile measurements of the gas concentrations are effective tools for investigating the spatial-temporal variabilities of CH_4 and carbon dioxide (CO_2) emissions from urban areas.

In this study, CH_4 and CO_2 fluxes were measured at two locations in Sakai, Osaka, Japan, using the open-path eddy covariance method since 2018. The area of the city is about 150 km^2, and its population is approximately 840,000 residents. The site surrounding the city center (SAC) was characterized as a densely built-up, consisting of industrial, commercial, and residential areas. The site located at an edge of the university (OPU) was characterized as suburb, consisting of university buildings, vegetation, and residential areas. The mobile measurements of gas concentrations were conducted around the two sites using a vehicle at the summer of 2019.

The SAC site emitted CH_4 and CO_2 throughout the year. The CO_2 fluxes showed clear diurnal and seasonal variations. The CH_4 fluxes also showed a clear diurnal variation, but an unclear seasonal variation. Based on a mean diurnal cycle in the CO_2 flux, high CO_2 emissions were observed during the daytime whose peak was around 12AM. The daytime maximum, over 20 μmol m^{-2} s^{-1}, was approximately ten times greater than the nighttime minimum. In all seasons, CO_2 fluxes increased during the daytime, whose variations were similar to traffic counts nearby the site. The CO_2 fluxes also showed clear seasonal variations with two peaks in the summer and winter. In the seasonal scale, emissions from gas-powered air conditioners may increase CO_2 emissions in the summer and winter. Based on a mean diurnal cycle, the CH_4 fluxes had a daytime maximum, over 40 nmol m^{-2} s^{-1}, around 3PM, which was approximately four times greater than a nighttime minimum. The high CH_4 emissions during the daytime could be caused by high emissions from the vehicle traffic, natural gas consumption, and/or sewerage systems in the daytime. Since the diurnal cycle of the CH_4 flux in SAC was lagged after the CO_2 fluxes, CH_4 emissions from other than vehicle traffic could also contribute to the diurnal variations in CH_4 fluxes. The CH_4 fluxes would increase in the summer and winter as well as CO_2, if emissions from imperfect combustions of natural gas, such as gas-powered air conditioners, contributed in the seasonal scale.

The OPU site emitted CH_4 throughout the year, but CO_2 uptake was observed in the summer. The CO_2 fluxes measured in OPU decreased in the summer owing to photosynthetic uptake by vegetation. Based on a mean diurnal cycle, the CH_4 fluxes had a daytime maximum, about 50 nmol m^{-2} s^{-1}, around 12AM, which was approximately three times greater than the nighttime minimum. Although the diurnal variations in the CH_4 flux were observed in both the summer and winter, the daytime maximum was greater in the summer than other seasons. Consequently, for the seasonal scale, higher CH_4 fluxes were observed in the summer than other seasons.

In the mobile measurements, CH_4 and CO_2 concentrations showed different spatial variations. Since CO_2 concentrations sharply increased during traffic jams and stops, vehicle-exhausted gases could increase CO_2 concentrations. These variations support the hypothesis that the diurnal variations in CO_2 fluxes in SAC were caused by the vehicle traffic. For CH_4 concentrations, the increases associated with traffic jams were not observed. This suggests that the contribution of emissions from vehicle exhaust gas could be larger for CO_2 than CH_4. Previous studies in United States reported high CH_4 concentrations were observed due to natural gas leaks from distribution pipelines, but such high concentrations were not observed in this area. In some locations, the increase of CH_4 concentrations were not reproducible. Further measurements should be required for identifying spatial-temporal variations in the gas concentrations in the urban area.

P1-F2

Seasonal dynamics of carbon uptake and release and their climate controlling factors in the North Hemisphere terrestrial ecosystems

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Given the important contributions of terrestrial ecosystem photosynthesis and respiration to global land carbon cycle, accurate depicting the seasonal dynamic of terrestrial gross primary productivity (GPP) and ecosystem respiration (RE) is important. Here, we analyzed seasonal patterns of GPP and RE using eddy covariance data from 116 north hemisphere stations with a temporal coverage longer than 3 years. The study included boreal, continental, temperate, and Mediterranean deciduous and coniferous forests, grasslands, shrublands, and wetlands, rainforest, arid grassland and shrublands, and polar and alpine coniferous forest, grasslands, shrubland, and wetlands. We found that the seasonal dynamics of GPP and RE were unimodal (except rainforest) and the dynamic of RE was coupled with the dynamic of GPP, high GPP corresponded to high RE and low GPP corresponded to low RE. The seasonal dynamics of grasslands were more fluctuated than other ecosystems, which was most pronounced in the Mediterranean. The maximum value of daily GPP (GPP_{max}) in coniferous forests was less than the GPP_{max} in deciduous forests. From temperate to boreal, the growing season length (GSL) and the growth respiration period (GRP) of ecosystems were significantly shortened. The spatial variations in annual GPP were mostly explained by the spatial variations of GSL and mean daily GPP (GPP_{mean}). Similarly, the spatial variation of annual RE dependent on GRP and mean daily RE (RE_{mean}), and RE_{mean} played a more important role than GRP. The spatial variation of GSL and GRP were determined by autumn minimum air temperature, and GPP_{mean} and RE_{mean} were influenced by annual precipitation. The overall results of this study will improve our understanding of the spatial patterns and climate controls of seasonal dynamics of ecosystem photosynthesis and respiration and thus can help to validate models that simulate changes in the global carbon budget.

P1-F3

Attribution of Lake Taihu evaporation change simulated by CLM4-LISSS model on the basis of future scenarios data

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Under the hydrological process, Lake evaporation is key factor which drive and affect water cycle, carbon and energy cycle are also included. Lake acts as sentinel function and has a quick respond for many ecology systems transformations affected by climate change. On the premise of climate change, the increase range of lake surface temperature is slower than air temperature and climate change will affect the lake's thermal and mixing condition and speed up the vulnerability of lake ecology. We use the several years eddy flux dataset collected from Lake Taihu Eddy Flux Network to evaluate the CLM4-LISSS model's key parameters and prove the offline simulated result of CLM4-LISSS model is available for us to apply in Lake Taihu latent heat flux's future simulation according to the comparison result, then we apply revised CLM4-LISSS model to simulate different future scenarios' Latent heat flux of Lake Taihu during 2006 to 2100, which powered by multi earth system models' meteorological data. All four future scenarios' latent heat flux shows significant increase trend, which in RCP 8.5 scenario owns the highest increase rate (2.55 W/m2 per decade), then two method is taken to analyze main driver of the Lake Taihu's latent heat flux change, statistical method (multiple stepwise regression method) result shows downward shortwave radiation is main contributor of lake latent heat flux variation, mechanistic method (the intrinsic biophysical theory) demonstrates the increase of latent heat flux is attributed to the term of atmosphere forcing and surface feedback.

P1-F4

Seasonal and interannual variations in carbon fluxes in East Asia semi-arid grasslands

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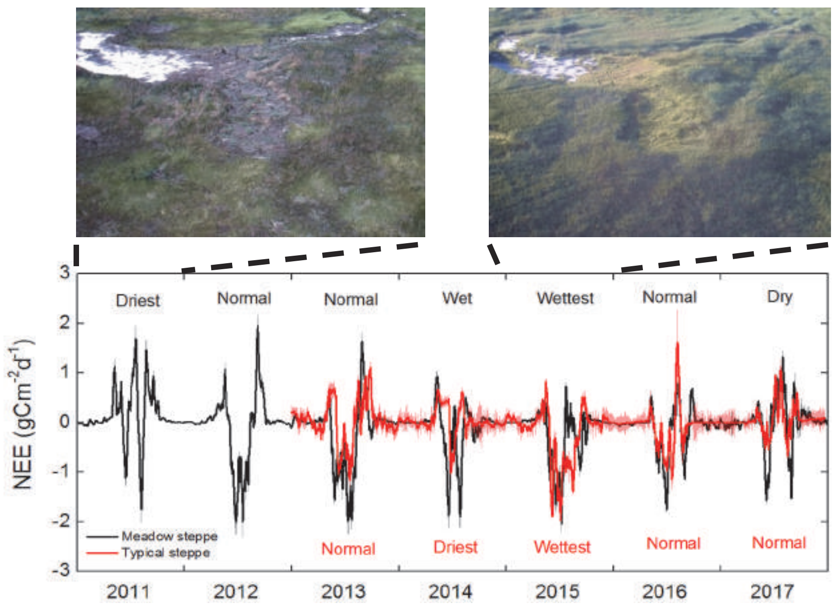
Semiarid regions have substantial interannual variation in carbon exchange between terrestrial ecosystem and atmosphere but the diverse responses of carbon fluxes to climate variability are poorly known. We compared carbon exchange processes and the responses to environmental factors in a meadow steppe at Tongyu (TY) and a typical steppe at Maodeng (MD) using long-term continuous eddy covariance measurements. TY precipitation was 25% greater than MD. Both grasslands had interannual fluctuations of carbon sink and source and acted as weak carbon sinks averagely (-22.9 ± 41.0 $gCm^{-2}yr^{-1}$ for TY and -11.8 ± 45.0 $gCm^{-2}yr^{-1}$ for MD). The seasonal dynamics of carbon fluxes were significantly related to water availability at MD but more strongly related to air temperature at TY. During dry years, the controlling effect of water availability on carbon fluxes increased. Summer precipitation and soil moisture played key roles in the interannual variations in carbon fluxes in both grasslands. At MD, net carbon uptake was negatively related to summer air temperature likely because warming induced water deficit decreased photosynthesis. Greenness index derived from PhenoCam images captured key phenological phases and diverse magnitude of canopy dynamics. The index was correlated with seasonal and annual variations in carbon fluxes at both grasslands, suggesting the potential of PhenoCam for monitoring the spatial and temporal variations in canopy dynamics in different semiarid grasslands.



P1-F5

An evaluation of the flux-gradient and the eddy covariance method to measure CH_4, CO_2, and H_2O fluxes from small ponds

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Despite their small overall area, small ponds play a large role in the greenhouse gas budgets of inland water bodies. According to Holgerson and Raymond (2016), despite occupying less than 8.6% of the total water surface area, very small ponds (area smaller 0.001 km^2) contribute disproportionately 15% of the total CO_2 emission and 40% of the total CH_4 emission from inland waters. Currently large uncertainties exist in these estimates. These uncertainties are not only related to the uncertainty of the area, number and spatial distribution of small ponds but also related to the sparsity of the actual flux observations. More flux measurements at small ponds are needed in order to reduce these uncertainties and to improve our understanding of the role of aquatic ecosystems in the global greenhouse gas cycles. This study aims to evaluate the performance of the flux-gradient (FG) and the eddy covariance (EC) method for measuring the fluxes of CO_2, CH_4 and H_2O at two small fish ponds (fetch < 120 m) in subtropical climate conditions. The EC fluxes were subject to two sources of error: high frequency flux loss and footprint contamination. Of the three gaseous fluxes, the CH_4 flux suffered the largest high frequency loss (18 %) due to a combination of low EC instrument height and long optical path of the CH_4 analyzer. Despite the low measurement height, the EC fluxes were influenced by sources outside the boundary of the target fish ponds, with the footprint contamination most severe on the CO_2 flux and least severe on the CH_4 flux. With regards to the FG method, one major uncertainty lies in the eddy diffusivity calculation. Of the three eddy diffusivity models evaluated [the aerodynamic (AE) model deploying the full Obukhov stability correction, the modified Bowen-ratio model using H_2O as a tracer, and the wind profile model for neutral stability], the AE model yielded the best results for the CO_2 and CH_4 fluxes. Our results support Horst's (1999, Boundary-Layer Meteorology 90, 171) theoretical prediction that the footprint of the AE flux based on a two-level concentration profile measurement should be much smaller than that of the gradient flux footprint and the EC flux footprint at the geometric mean of the two heights. We conclude that the most appropriate micrometeorological method for measuring fluxes from small water bodies is a hybrid scheme, whereby an EC system is deployed to measure the eddy diffusivity and a precision gas analyzer is used to obtain the concentration gradient of the target gas.

P1-F6

Driving factors of changes in evapotranspiration from a red pine ecosystem

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Understanding the controls on evapotranspiration (ET) is important to predict future water resources and regional climate (Kelliher et al., 1993). In general, ET is controlled by various driving factor such as net radiation, vapor pressure deficit, soil water content and leaf area index, but these drivers complexly affect the variation of ET due to the inter-factor dependencies. Futhermore, vegetation sensitivity to these factors varies by ecosystems (Stoy et al., 2006, Igarashi et al., 2014). Thus, accurate prediction of ET requires more detailed understanding of ecosystem characteristics in evapotranspiration. In this study, we examined controls on ET from a red pine ecosystem using 12-year data, and applied the perturbation analysis to separate the effects of driving factors to the change in ET.

The ecosystem studied is a coniferous red pine forest with some below-canopy deciduous trees located in the northern foot of Mt. Fuji in Fujiyoshida, Yamanashi, Japan. The latent heat flux (LE) using the eddy covariance technique and some climatic parameters were measured on the forest floor and above the canopy. Data gaps of above-canopy LE values were filled by multiple imputation method (Hui et al., 2004). Canopy conductance was calculated by inverted Penman-Monteith equation.

The annual maximum above-canopy LE (LE_c) was observed in August and the monthly average was about 90 W m^{-2}. Diurnal variation of LE_c was driven by solar radiation (Rs), vapor pressure deficit (D) and canopy conductance (g_c) as similar to previous studies, however significance in drivers changed seasonally; effect of Rs and D increased in summer and g_c effect increased in winter. The stomata tend to close during winter, weakening the effect of Rs and D. Annual total LE_c was most affected by D. Stomatal response to changes in D can be moderate for humid ecosystems (Igarashi et al., 2014), and also nighttime evaporation could be higher in high D condition.

To estimate contributions of forest floor LE on above-canopy LE, we examined driving factors of forest floor LE. A monthly average of forest-floor LE (LE_f) was the highest in May and the value was about 10 W m^{-2}. LE_f was driven by D and net radiation (Rn), but LE_f was more affected by D than Rn. Therefore we made an empirical formula with driving factor D, with transport efficiency and evaporation efficiency by wind speed (U) and soil moisture content respectively. Estimates of spring (March-May) and summertime (June-August) LE_f were relatively close to observed LE_f. The linear relationship between observed LE_f and D multiplied with U showed that the slope was larger in morning (12.5) than afternoon (3.2) and this was remarkable in winter. We speculate that the morning LE_f was affected by either evaporation of condensed water on the ground or dry air penetration from the air above the canopy.

We will present the results from the perturbation analysis to quantify the contribution of driving factors to the variation of LE at the poster.

P1-F7

The controlling factors of diffusive and ebullitive methane emission on sub-daily time scale at a mid-latitude shallow lake

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Lakes are one of the main sources of methane (CH_4), an important greenhouse gas. CH_4 is produced in anoxic lake sediments by methanogenic bacteria, and it is emitted to the air via diffusion within the water column, diffusion within plant aerenchyma, and ebullition.

For more precise prediction of CH_4 emission from lakes, it is essential to clarify the mechanisms of diffusive and ebullitive emission on sub-daily time scale using continuous data of CH_4 flux. In the previous studies, floating chambers or bubble traps were generally used for measuring CH_4 flux from lakes. However, its spatial coverage and temporal resolution are limited. In this study, we applied a partitioning technique to CH_4 flux measured with the eddy covariance technique in a mid-latitude shallow lake, and examined the mechanisms of the CH_4 emission via diffusion and ebullition on sub-daily time scale.

The measurement was conducted in Lake Suwa, a shallow eutrophic lake located in the center of Nagano prefecture, Japan. The eddy covariance system was installed on a pier (36°2’47.66”N, 138°6’30.07”E) located at the south-east shore of the lake. The diffusive and ebullitive CH_4 flux were calculated using the 10 Hz data of ultrasonic anemo-thermometer and open-path CH_4 analyzer at 30-min interval with a modified eddy covariance technique (Iwata et al., 2018), which partitions the total flux into diffusive and ebullitive fluxes. Along with the eddy covariance measurement, we obtained 30-min averages of wind speed, atmospheric pressure, water temperature profile, water level, and radiation. We used data from July 4, 2016 to August 30, 2017.

Both diffusive and ebullitive flux were significantly higher in the summer than in the winter, reflecting enhanced CH_4 production in the lake sediment in warmer months. The ratio of annual cumulative ebullitive flux to the total flux was 0.59.

Mean diurnal variation showed that diffusive flux became high in the afternoon, when wind speed also became high, in every seasons. Diffusive flux increased with the increase of wind speed due to enhanced gas transfer efficiency. This wind speed dependence is consistent with those obtained with other methods such as floating chambers or transfer velocity method (e.g. Erkkilä et al., 2018).

Ebullitive flux during winter showed that higher flux (>0.05 μmol m^{-2} s^{-1}) was more frequently observed in the morning when wind speed started to increase, and few high flux was observed in the afternoon. However, in the summer, high ebullitive flux occurred at any time of day and no clear diurnal variation was observed. Environmental dependence of ebullitive flux showed that high ebullitive flux tended to be observed when hydrostatic pressure decreased and wind speed increased. These results are consistent with previous studies in which the decreasing hydrostatic pressure and bottom shear stress caused by wind are considered as a trigger for the ebullition. Such a tendency was clearer in the summer than in the winter. The different sensitivity of ebullition on the environmental conditions between seasons may be partly explained by the amount of bubble stored in the sediment. In the cold season, when high ebullitive flux occurred at night, the ebullitive flux in the morning was generally smaller than ~0.05 μmol m^{-2} s^{-1}. When ebullitive flux was relatively small (<0.05 μmol m^{-2} s^{-1}) during night, high ebullitive flux tended to be observed in the morning. This suggests that winter ebullition is also limited by the amount of bubble in the sediment, in addition to the hydrostatic pressure and wind. On the contrary, summer ebullition is less limited by the amount of bubble in the sediment. In the summer, the amount of accumulated bubble would be high due to high CH_4 production rate, which supports high ebullition at any time of day.

P1-F8

How to register your observation data to European Flux Database?: Toward open data policy of JapanFlux data

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JapanFlux is now promoting dataset submission to European Flux Database to increase the visibility of our datasets to wide communities. Therefore, we are working on preparing datasets to convert and register to European Flux Database. In this presentation, we show how to register observation data into European Database and discuss the potential benefit of the registration. We found that the data registration process is not so much complex and many users can easily put their datasets to the database. Furthermore, we can get feedback from European Flux Database group on the submitted data, in particular for incorrect data format and unit and questionable data. Advantages of open data via European Flux Database are: (1) to improve visibility from research communities and (2) simple link to the FLUXNET database. We can also help to upload more data from both JapanFlux and AsiaFlux.

P1-F9

Exploring influences of different management strategies on surface energy patterns in tea fields

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Understanding characteristic of different agricultural land use and land cover is one of the important issues for land management and agricultural practices. Management strategies of agricultural fields applied by farmers could play an important role to influence energy budget near the ground surface over different scale. Although some surface energy budget has been evaluated in different kinds of cash crops, quantitative comparison of energy components in tea field with row-planting and short canopy properties is still rare. Tea is important cash crop as major income for farmers in northern Taiwan. Dealing with the impact of weather fluctuation to ensure the sustainability of the tea farms is an major concern for tea farmers in this region. For field management, the main purpose is to conserve moisture in tea field for more yield and higher production quality. To achieve these objectives, tea farmers use their knowledges to manage their fields with different ways. This study tried to quantitatively characterize the impacts and resilience of the tea farms with different management strategies by quantifying energy components in two neighboring tea fields with two different canopy structure caused by two management practices, conventional and organic-certified. Two sets of eddy-covariance (EC) system coupling with environmental observation system have set in tea fields with different canopy structure during winter and summer. Different patterns of energy budget under different management strategies in these two neighboring tea fields are evaluated. The results could sufficiently help farmers to understand the characteristics in their fields, provide an quantitative information for sustainable development in field management in the future, and help to develop more precisive regional climate model for researchers.

Keywords: Perennial cash crop; Row-planting; Eddy-covariance; Flux; Energy budget

P1-F10

Inter-annual variability of net ecosystem exchange of CO_2 in a temperate deciduous forest in the Gwangneung National Arboretum in Korea

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Gwangneung temperate deciduous forest KoFlux site (GDK) is one of the longest surface flux measurement sites in Korea. In this report, we focused on the inter-annual variability of net ecosystem exchange of CO_2 (*NEE*) and its controlling factors. This oak-dominated mixed forest (e.g. *Quercus serrata*, *Carpinus laxiflora*) is at least 80 years old and has been naturally preserved as a part of the national arboretum with no management. The mean canopy height is approximately 20m and the soil type is predominantly silt loam. During the study period from 2004 to 2018, annual temperature was 11.1±0.6 °C and precipitation was 1361±360 mm. Eddy covariance fluxes were measured at 40 m above ground using a sonic anemometer, open- and closed-path infrared gas analyzers. Data processing, quality control, and gap-filling were performed, following the KoFlux protocols. First, we quantified the inter-annual variability of *NEE* and then examined the biophysical factors that may have caused a year to year variation. Second, we interpreted these results on the basis of Odum's strategy of ecosystem development (SED) theory. During the 15-year period, 2004 and 2005 were excluded from the analysis (due to large data gaps). For the remaining period from 2006 to 2018, the mean *NEE* was −50 (±107) gC m^{-2}, indicating that the GDK forest was on average a weak carbon sink with large inter-annual variability. The relationships of climatic (light, air temperature, precipitation) and phenological factors (growing season length) with *NEE* variation were rather complex and yet light explained largest portion of the inter-annual variance, as expected. The scrutiny of such inter-annual variations demonstrated that the GDK forest was sensitive to changes in their environmental conditions by showing frequent shifts between weak carbon sink and weak carbon source. Particularly with weakened or absence of intensive summer monsoon for the recent several years, the forest has been turning from carbon sink to carbon neutral and further into carbon source. Despite a wide range of variations in climatic and phenological conditions, the ratio of gross primary productivity (*GPP*) to ecosystem respiration (*RE*) remained relatively stable with an average of 1.05 (±0.09). In terms of water use, the efficiency (defined as the ratio of *GPP* to evapotranspiration) also showed insignificant interannual variations. These results are further examined and discussed from the perspectives of thermodynamics and network growth.

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Soil respiration after six years of continuous drought stress in the tropical rainforest in Southwest China

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Climate models predict that droughts will increase in Southeast Asia, yet little is known about how soil respiration (Rs) and its components heterotrophic respiration (Rh) and autotrophic respiration (Ra) will change following drought years. To clarify this issue and to detect underlying mechanisms, we conducted a 2-year field experiment in the seventh and eighth year of long-term stress experiment at artificially droughted plots within a tropical rainforest in Xishuangbanna, southwest China. We separated Rh and Ra by trenching and we measured dissolved organic carbon in the soil water and microbial biomass. In average, the drought stress (a through-fall reduction treatment), reduced through-fall by 50%, reduced fine root biomass by 36%. Ra declined by 35 % yet Rh increased. There was a 31% increase in active inorganic nitrogen with a 29% increase in Rh. Further, the change in soil microbial community composition, mainly, group-specific phospholipid fatty acid could explain 17%-59% of the spatial variation of Rh during the dry and rainy season of 2018. However, changes in dissolved organic carbon, microbial biomass carbon and nitrogen, ammonium nitrogen, did not explain the increase in Rh (+29%). There was an inconsistent significant positive correlation between seasonal change of CO_2 flux and these processes dynamic across 2017 and 2018. Soil temperature, soil moisture and litterfall jointly determined annual variation in Rs and Rh across two years. These findings highlights the different response and mechanism of root and soil microorganisms to long term drought stress.

Keywords Soil respiration. Soil temperature. Soil moisture. Autotrophic respiration. Heterotrophic respiration. Through-fall reduction

P1-S2

Nitrogen addition decreased soil respiration by altering microbial composition without changing the temperature sensitivity in a semiarid grassland

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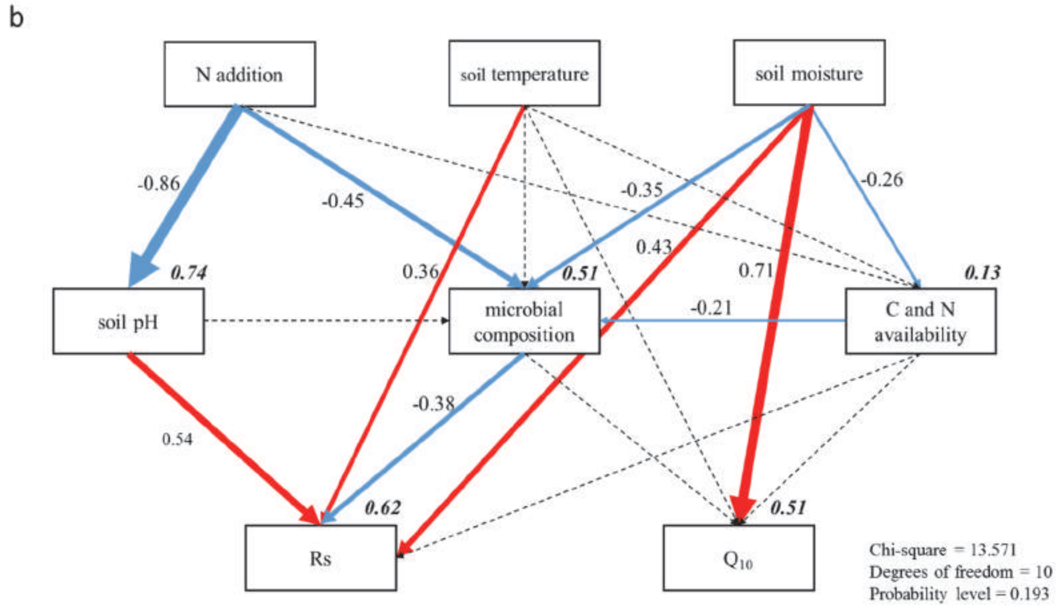
The mechanism underlying the response of soil respiration (Rs) to nitrogen (N) addition remains to be explored in semiarid ecosystems. This study was conducted to determine the effect of N addition on soil microbial composition, Rs and its temperature sensitivity (Q_{10}). A N addition experiment was carried out in a semiarid grassland in China, with N fertilizer application rates of 0, 2, 4, 8, 16, or 32 g N m^{-2} yr^{-1} for three consecutive years. Microbial phospholipid fatty acids, Rs and Q_{10}, and their relationships with soil properties were measured. Results showed that N addition significantly increased the content of soil dissolved organic carbon (DOC) and inorganic nitrogen (IN), and decreased soil pH. N addition reduced microbial biomass carbon (MBC), reduced fungi to bacteria ratio (F:B) and increased gram-positive bacteria to gram-negative bacteria ratio (G+:G-). The results of structural equation model showed that soil moisture was the main regulator of Rs. N addition reduced Rs by lowering MBC and altering microbial composition. However, N addition had no significant effect on Q_{10}, soil total organic carbon (TOC) and total nitrogen (TN), indicating that N addition alleviated soil carbon loss and was unlikely to change its potential for bigger loss under global warming.



Structural equation model for the effects of nitrogen addition, soil temperature and moisture on soil pH, C and N availability, microbial composition, Rs and Q_{10}.
Dashed, red, and blue path indicates the effect is insignificant, positive, and negative, respectively. The width of the arrow indicates the strength of the standardized path coefficient. Bold and italic-typed value indicates the proportion of the variance explained for each variable.

Isoprene emission from bamboo species

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Isoprene is abundantly emitted by terrestrial plants and is one of the largest volatile organic compound (VOC) emission whose carbon weight approximately equal to that of the emission of methane in the globe, leading it becomes a significant carbon pathway in terrestrial ecosystems. Besides of its abundance, the high reactivity of isoprene can impact the atmospheric chemistry, for example, isoprene and its oxidant can contribute to the formation of ozone (O_3) and secondary organic aerosols (SOAs), which are significant air pollutants; also, isoprene can prolong the lifetime of methane (CH_4) by competing radicals with it. Therefore, clarifying the isoprene emission from vegetations has its importance on atmospheric chemistry including control of air quality, estimation of greenhouse gases and clarification of carbon cycling.

Isoprene emission from vegetation have been studied on many species over the world, however, only few studies focused on isoprene emissions from bamboo species. Bamboo species have widely distributed in the world and across regions with different climate type including tropical, subtropical, and temperate regions. Currently, bamboo forests have showed expansion and invasion in eastern Asia, especially for species with running rhizomes, such as *Phyllostachys pubescens* (moso bamboo). Several studies reported that some of the bamboo species, e.g. *P. pubescens*, *Phyllostachys bambusoides* and *Bambusa oldhamii*, can be isoprene emitters, implying potential impact on regional isoprene emission under the expansion of bamboo forests.

Previous studies of isoprene emission from bamboos only investigated the isoprene emission for a short term (about one day) with limited light and temperature changes. To clarify the isoprene emission characteristics, which is essential for clarifying regional impact under the expansion of bamboo forests, the dependence on several factors, including light intensity and leaf temperature, should be investigated. Thus, we observed isoprene emission fluxes from leaves of *P. pubescens* with light control during measurements in a pure forest of *P. pubescens* located in Xitou experimental forest of National Taiwan University, Nantou, Taiwan from September 2015 to March 2016.

We found that the isoprene emission fluxes increased with photosynthetic photon flux density (PPFD) then saturated at PPFD of ~1000 μmol m^{-2} s^{-1}, which can be reproduced with a G93 model for isoprene emission flux from plant leaf. On the other hand, under sufficient light, isoprene emission flux increased with leaf temperature, however, it did not be reproduced with the G93 model because of the very low emission flux at leaf temperature lower than 23°C and steeply increased emission flux with leaf temperature (Fig 1).

In this study, *P. pubescens* showed strong isoprene emission fluxes which are comparable to top-class emitter species at standard condition. The steeper increase in emission flux with leaf temperature could be explained by the different regulatory mechanism between tropical/subtropical species including *P. pubescens* and temperate species which were the empirical parameters of the G93 model conducted from.

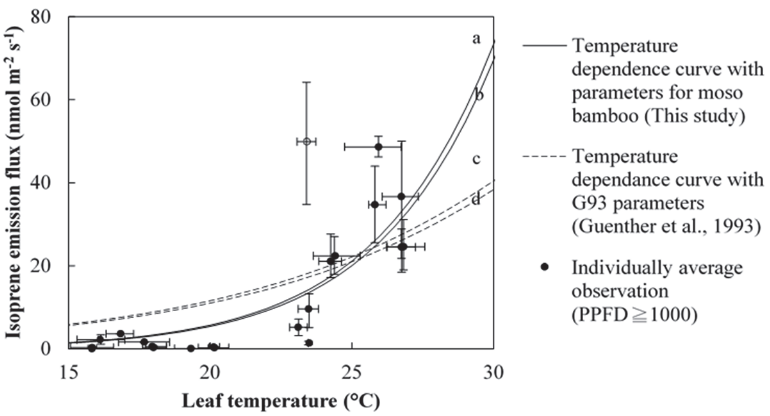

Fig 1 Isoprene emission fluxes from leaves in relation to leaf temperature by culm (solid and open circles) with highest and lowest measurements (error bars) under sufficient light. The solid and dashed curves represent the simulation by ordinary G93 algorithm and optimized G93 determined in this study.

P1-E1

The effect of lost canopy on the seasonal variation of stem surface respiration in Japanese cedar

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It is well known that Japanese cedar forest, which is typical ecosystem in Japan, is damaged by heavy snow in cool temperate zone. In addition, a recent future climate study has predicted that extreme snowfall events will increase in central Japan under ongoing climate change. Thus, the occurrence of snow damage in Japanese cedar forest in this region will increase in the future. It is, therefore, important to understand the effect of disturbance caused by snow damage on photosynthesis and each respiration components on carbon cycle in this forest. As the stem surface respiration is one of the largest respiration components in forest ecosystem, we clarify the effect of lost canopy by snow damage on the seasonal variation of stem surface respiration in Japanese cedar.

Our study was conducted at evergreen coniferous forest in Takayama, Japan (AsiaFlux TKC; 36°08'N, 137°22'E). At the site, many individual trees were damaged by heavy snow in December 2014 and lost all or parts of canopy. In this study, we categorized the 21 individual trees into the following three types based on the canopy conditions: healthy tree (H), broken stem tree but canopy still intact (BSc), and broken stem tree with no canopy (BS). From April to December in 2018, we measured stem surface respiration, stem surface temperature and diameter at breast height of all individual trees. Additionally, we collected tree-ring core samples to confirm the annual ring formation and collected woody tissues for observation of cambial activity of BSc and BS. We also estimated canopy projected area of H and BSc.

Stem surface respirations of all samples had clear seasonal variation with highest in summer and lowest in winter. As a result of the comparison of stem surface respirations under different canopy conditions, stem surface respiration in H and BSc were highest and lowest throughout the measurement period, respectively. In addition, temperature dependence of stem surface respiration under three canopy conditions were different. The different respiration rate and temperature sensitivity might be caused by different respiration process among H, BSc and BS as follows: Stem surface respiration in H might consist of the growth and maintenance respiration. In fact, we found the clear relationship between the annual stem surface respiration and annual stem radial growth in H. Almost stem surface respiration in BSc might consist of maintenance respiration because almost all individual trees of BSc have living cambium in despite of the lack of the annual rings after the year of canopy damage. Stem surface respiration in BS might consist of microbial respiration because the cambium of all of BS had already dead. Consequently, our analysis indicates that the spatial heterogeneity of stem surface respiration is increased by snow damage in the Japanese cedar ecosystem.

P1-E2

Eddy covariance reveals the seasonal patterns in energy balance and evapotranspiration from an alpine *Sphagnum* peatland in the Australian Alps

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Australia's alpine *Sphagnum* peatlands are nationally significant ecosystems, for their biodiversity values and playing an important water quality role in the headwaters of SE Australia; yet they are also listed as endangered. In order to protect and sustainably manage these ecosystems, a greater understanding of their hydrology is needed. In particular, peatland evapotranspiration remains poorly characterized due to the complexity of surface characteristics and the diversity of peatlands (i.e. condition, age position in landscape etc). This study examined the evapotranspiration dynamics and the energy balance, of an alpine *Sphagnum* peatland under differing meteorological conditions for two years. Energy and water vapour fluxes were determined continuously using the eddy covariance approach. Potential evapotranspiration was computed via the modified Penman-Monteith approach. Measured fluxes were characterized by a distinct seasonal pattern with the highest values observed during summer. The closure of the energy balance of the in-situ measurements was acceptable (slope = 0.71, $r^2 = 0.90$). Spring, summer and autumn show a distinct diurnal pattern of latent and sensible heat fluxes, with the highest average values observed between 10:00 and 14:00. In summer, the values of latent heat obtained in the daytime account for an average of 40–60 % of the radiation balance, while the Bowen ratio has a value of 0.3 to 0.7. Our results show that the seasonal average ET values were 43mm, 166mm, 343mm and 136mm in winter, spring, summer and autumn, respectively. The average daily total evapotranspiration varied from 0.5 mm d^{-1} during the winter months to 3–3.5 mm d^{-1} in summer. During the summer, daily evapotranspiration was closely related to the daily potential evapotranspiration. Synoptic weather conditions, as reflected by incoming radiation and water vapour pressure deficit, were the key factors controlling evapotranspiration. Differences in the precipitation patterns and summer temperature also accounted for some of the observed differences in evapotranspiration between the 2 years of the study period.

Keywords: Actual evapotranspiration; Bowen ratio; Eddy covariance; Energy balance; Peatland

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P1-E3

Does decomposition of leaf mixtures and absorptive-root mixtures synchronously change with deposition of nitrogen and phosphorus

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Leaves and absorptive roots, the plant tissues that acquire resources, decompose quite differently due to their distinct morphology, chemistry, and decomposition microenvironment. However, the mechanisms behind leaf mixture decomposition and root mixture decomposition and their responses to nutrient deposition remain poorly understood. We used a nutrient-addition manipulative experiment to investigate the individual and interactive effects of nitrogen (N) and phosphorus (P) on leaf mixture decomposition and absorptive root mixture decomposition of *Pinus massoniana* and *Schima superba* forests in subtropical China. Four treatments were employed: control (CTRL), +N (120 kg N $ha^{-1}y^{-1}$), +P (40 kg P $ha^{-1}y^{-1}$), and +NP (120 kg N and 40 kg P $ha^{-}1y^{-1}$). Both the leaves and roots decomposed faster when in mixture (observed) than in isolation (expected). The synergistic effects were decreased under all the nutrient-addition treatments for the leaf mixtures but only with +NP for the root mixtures. The differences (observed - expected) of the extracellular enzymatic activities (EEAs) of microorganisms were decreased with +N in the leaf mixtures relative to the CTRL, and the differences (observed - expected) of the concentration of acid unhydrolyzable residue (AUR) were decreased with +NP in the root mixtures. The differences (observed - expected) of mass loss were positively correlated with microbial EEAs differences for leaf mixtures and with AUR concentration differences for root mixtures. Our results indicated that the decomposition of both the leaf mixtures and the root mixtures had synergistic effects. The decreased synergistic interactions under nutrient addition were associated with microbial EEAs for the leaf mixtures and with AUR concentration for the root mixtures. These findings highlight the contrasting mechanisms underlying the decomposition of above-ground mixtures and below-ground mixtures, and imply a slow cycling of carbon and nutrients under atmospheric nutrient deposition.

Key words: Mixing effect; Litter decomposition; Fertilization; Nitrogen; Phosphorus; Synergistic interaction

P1-E4

Gas exchange process during and after rainfall over a Japanese cypress canopy by using eddy covariance and SVAT multi-layer model

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CO_2 flux (F_c) and latent heat flux (λE) dynamics over temperate forest canopy are very important for solving the problem of Global Warming and Greenhouse effect, because it reveals the gas exchange process. However, in many sites with frequent precipitation, there is a blank on understanding the gas exchange process during and after rainfall due to the low precision of traditional open path gas analyser in wet environment. Moreover, for hypo-stomatal vegetations, whether rainfall interception can distribute on the abaxial (lower) surface greatly effects stomata aperture.

This study used the method of eddy covariance with advanced water proof enclosed gas analyser to capture the gas exchange dynamic of a temperate hypo-stomatal Japanese cypress canopy over in 3 years and analyse stomatal activity by canopy conductance. Wetness monitoring by handmade wetness sensors were also carried out synchronously. The results showed there were higher F_c, λE at the 3 hours after wet than 3-6 hours after wet and over 6 hours dry periods when the meteorological conditions were the same (e.g. Figure 1). The similar trend of canopy conductance indicated higher stomatal conductance at the initially dry periods (3 hours after wet). The variations of gas exchange dynamic of different leaf wetness condition were not same through the seasons and especially significant in summer.

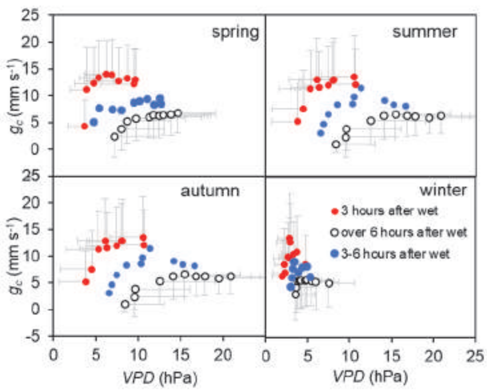

Figure 1. relationship between g_c (canopy conductance) and *VPD* at different wetness conditions in 4 seasons

Meanwhile., a SVAT model has been employed to detect the gas exchange during the rainfall by using two different rainfall interception solutions (Figure 2.: leaf wetness distributed on the adaxial surface and both surfaces). In five degrees of rainfall, cases that were close to both two models and representatively close to each model appeared. The results by positive λE and negative F_c during the rainfall as model 1 indicated that Japanese cypress were able to process gas exchange during the rainfall occasionally.

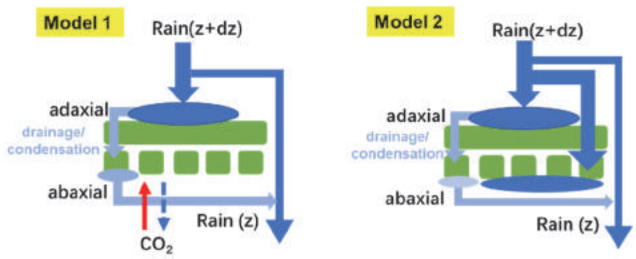

Figure 2. Conceptual figure of the two rainfall interception solutions

P1-E5

Tree root exudation with fine root traits under four coniferous forests in Japan

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Plant roots have the function of releasing organic compounds to the soil, which is useful for plant survival through the degradation of microorganisms around the roots and the enhancements of allelopathy against other plant invasions. In this study, we developed a method to collect exudative carbon content from tree fine roots in natural forest field. We quantified the root exudation rates in four conifers and the relationship with morphology and N contents, and aimed to determine influence of root traits on exudation.

The study was conducted in a cool temperate forest in Nagano, Japan. Target species with mature trees were red pine (*Pinus densiflora*), larch (*Larix kaemoferi*), Japanese cedar (*Cryptomeria japonica*) and cypress (*Chamaecyparis obtusa*). The intact root system was exposed from the soil without any disturbance and divided into three diameter classes (<0.5, 0.5-1.0, 1.0-2.5 mm). We measured exudation rate from the root system. The root samples were evaluated as root traits; diameter, specific root length ($m\ g^{-1}$), specific root area ($cm^2\ g^{-1}$), root tissue density ($g\ cm^{-3}$), and N concentration (%).

Fine root exudation rate increased with decreasing diameter in all species. Exudation rate was correlated positively with specific root length and root N and negatively with root tissue density. These results suggest that the roots with small diameter, high physiological activity, and low tissue density has high C release by exudation. Therefore, it may be possible to have high exudation rates by forming traits that are easy to exudate.

Keywords: Carbon flux, Secondary metabolite, Tree fine root, Rhizodeposition

P1-E6

Response of fine root respiration rate and morphology traits along the elevation gradient in Japanese subalpine forest

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The respiration of fine roots (<2 mm in diameter) is accounted for great part of soil respiration, and plays important role in carbon cycle in forest ecosystem. Fine root respiration and morphology could reflect plant growth and resource uptake. Here, we elucidated the respiration and morphology of fine roots of Birch (*Betula ermanii* and *Betula platyphylla*) and Fir (*Abies veitchii* and *Abies mariesii*) in response to elevation gradient in subalpine forest.

We established five plots (1500 m, 1600 m, 2000 m, 2300 m, and 2500 m) along the elevation gradients of Mount Norikura(3026 m above sea level) in central Japan. The mean annual precipitation is about 1600 mm, and the mean annual temperature is about 5 °C (1600 m). We measured the respiration of fine root system from five elevations in summer during 2018 and 2019. We investigate the respiration rates and morphology of fine roots divided into three diameter classes (<0.5, 0.5-1.0, and 1.0-2.0 mm) in the Birch and Fir species. At each elevation, the root system were sampled from the soil within 1 m from the trees. Fine root respiration was evaluated at about 20°C using an infrared gas analyzer (IRGA GMP343, Vaisala, Finland). The image data of the fine root system was created with a scanner after measurement of respiration. Root length, root volume, and mean diameter were measured with WinRhizo (Regent Instruments, Quebec, Canada). Specific root length and root tissue density were determined from the measurement data as morphological traits. We determined the root branching intensity (root tips per length) by counting the number of root tips from image data.

We will discuss the relationships between the respiration and morphology of fine roots along the elevation gradients in Japanese subalpine forests.

Key wards: root CO_2 efflux, elevation gradient, specific root length, root tissue density

P1-E7

Flower litters as hyper nitrogen- and phosphorus-rich resources for soil ecosystem

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In forests, leaf litter is ubiquitous for decomposers, but its nitrogen and phosphorus contents are usually very low. In contrast, flower litters contain more nitrogen and phosphorus than leaf litters in some species. However, decomposition process of the flower litters on the forest floor has rarely been compared with that of leaf litters.

Thus in this study, we first quantified litter properties (C, N and P contents and C/N) of flower litters, using 4 species (*Fagus crenata*, *Pterocarya rhoifolia*, *Quercus crispula* and *Aesculus turbinata*), and found that flower litters had very high decomposability. Then we prepared flower litter bags whereas leaf litter bags separately for these species, and placed them for 4 months under the canopy of each species in a temperate mixed-species forest. Results show that flower litters lost 13 to 46% of initial weight at the first 2 weeks and 42 to 77% at the end of the experiment and that leaf litters retained, in contrast, 80 to 90% of initial weight even at the end of the experiment (4 months later).We also found that nitrogen released from the flower litters accounted for 35 to 159 mg/100g litters at the first 2 weeks, whereas that release from leaf litters only 6 to 15 mg/100g.

Our study demonstrates that flower litters serve as very ephemeral resource for decomposers, providing a seasonal pulse to soil ecosystems.

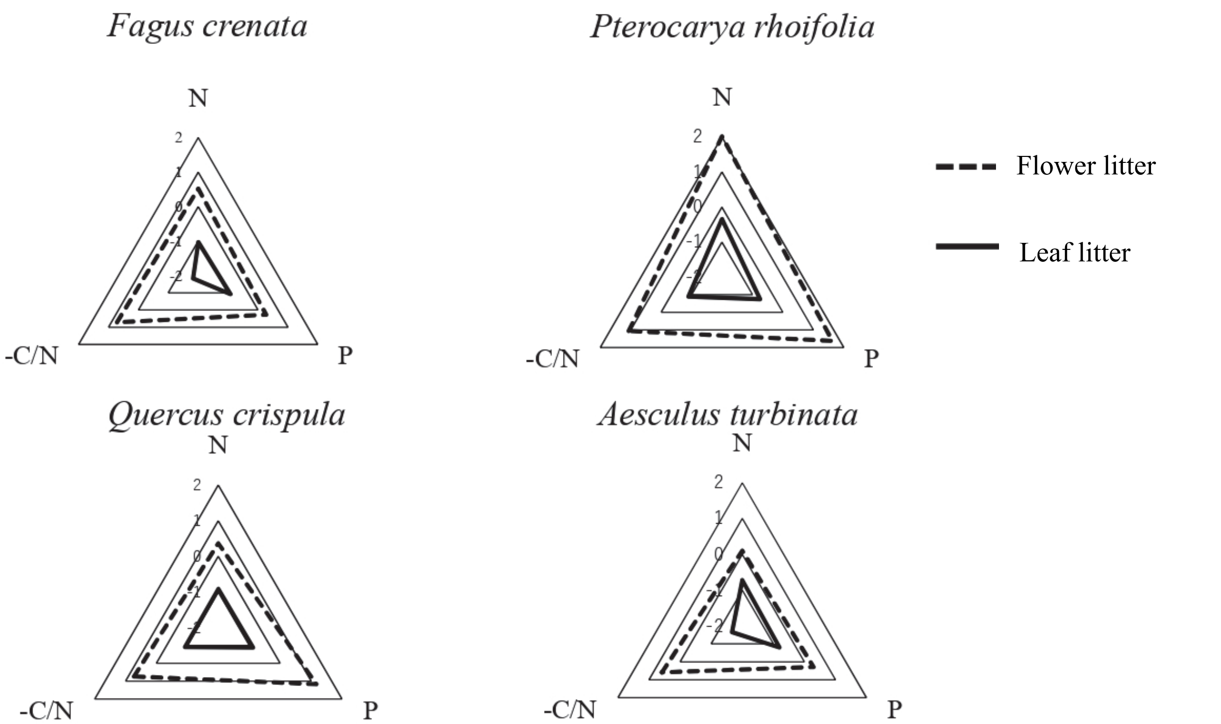

Figure1. Litter properties (C, N and P contents and C/N) of flower litters compare with leaf litters. Values are standardized within each of N, P and C/N. We used -C/N because this mean that that higher values represent higher decomposability.

P1-R1

Ground based measurement of solar-induced chlorophyll fluorescence dynamics in rice paddy field ecosystem

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Solar-Induced Chlorophyll fluorescence (SIF) is one of state-of-art proxies, representing the photosynthetic status. One of the unique characteristics of SIF, as a direct information on photosynthesis, is to be able to be extended from single-leaf scale to the ecosystem and global scale for estimating the gross primary productivity (GPP) simultaneously. It's been discovered that SIF had a strong correlation with photosynthesis activity at the leaf level and global level detected by satellite (e.g. GOSAT, FLEX) as well and, although large uncertainty has still remained in its mechanism. To understand more on SIF-GPP relationship, the ground-based measurement of the SIF should be conducted over various ecosystem types (considered climate conditions, plant species) in order to develop a higher accuracy model of global carbon cycling. Rice paddy field is one of the major crops in Asia, occupying about ninety percent of the world total paddy area. Therefore, detecting the GPP via remote-sensing information is useful to know how much of atmospheric CO_2 taking by plant through photosynthesis. For SIF detection, we installed a high-resolution spectroradiometer, QEpro (Ocean Optics, Dunedin, FL, USA) with the full-width at half maximum (FWHM) of 0.30 (Ocean Optics, Dunedin, FL, USA), in rice (*Oryza sativa* L.; cultivar Koshihikari) field at Mase eddy flux site in Tsukuba city in Japan. The spectroradiometer is connected to three optical fiber cables, the first one is for detecting the incoming solar irradiance (field of view, FOV at 180°), and second and the third one is for detecting the upcoming reflected radiance from paddy field (FOV at 25° and 180°, respectively). The diurnal and seasonal dynamics of SIF were compared with photosynthetically active radiation (PAR) and the other vegetation indices; namely the normalized difference vegetation index (NDVI), and Enhanced Vegetation Index (EVI). The SIF was also conducted from different 5 spectroradiometers (FLAME, HR4000 x 2, QE Pro x 2) with 0.11-0.66 nm of FWHM. In this study, the ground-based assessment results of SIF variability in the ecosystem are the preliminary results towards the process of validating the photosynthesis yield at the global level.

P1-R2

Mapping the forest aboveground biomass in Japan by SAR-based machine learning model

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Forest plays an important role in the global carbon cycle. Estimating its biomass is quite important for understanding the carbon dynamics of the terrestrial ecosystem and climate processes. While passive optical remote sensing has difficulty to capture the direct information of forest canopy structure, active microwave radar can do it by penetrating the forest canopy and by the weather- and light-free detectability. The combination of multi ground data can also improve estimation accuracy than those generated by an individual sensor (Saatchi et al.,2011; Qin et al., 2016).

In this study, we applied the machine learning model, random forest regression model, trained by the Phased Array L-Band Synthetic Aperture Radar (PALSAR) series data operated by JAXA from 2006, and multiple remote sensing data, including vegetation indices and topography etc., for detecting aboveground biomass (AGB) in Japanese forest. We used the PALSAR 25m mosaic data with HH and HV polarizations. To reduce the speckles, we also did a filtering with averaging window size of 5 x 5 pixels. The MCD43A4 product of Moderate-Resolution Imaging Spectroradiometer (MODIS) was used to calculate the normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI). To improve the estimation accuracy, the statistics in temporal variation (average, standard deviation, range, skewness, kurtosis) and textures (mean, standard deviation, entropy, homogeneity, contrast, dissimilarity) of them are also used for model training, together with the 90 m spatial resolution Shuttle Radar Topography Mission (SRTM) product. In this study, random forest (RF) regression algorithm was used to determine the optimal variables of statistical models for estimation and validation of forest AGB derived from the ground survey of them by Japanese Forest Agency. As Yu & Saatchi (2016) found that it is important to consider the forest types when using L-band backscatter to estimate forest AGB, we run the RF models for each forest type.

The objectives of this study are to (1) map the forest AGB in Japan using a combination of PALSAR and others, (2) to quantify the spatiotemporal forest changes in Japan from 2007 to 2010.

Keywords: L-band ALOS/PALSAR; MODIS; random forest.

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P1-R3

Precipitation-use efficiency in Eurasian steppe: spatial pattern and influence factors

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Study on the response and adaptation of terrestrial ecosystem carbon and water cycle processing on climate change has become one of the key issues in ecology and global change science. Precipitation-use Efficiency (PUE) is an ecological parameter to measure the efficiency of biomass production using precipitation resources in terrestrial ecosystems. It is of great theoretical significance to reveal the spatial variation pattern and its formation mechanism of PUE to assess the change of production and to understand adaptive strategies of terrestrial ecosystem. Our study was based on above-ground biomass sample point data and GIMMS Normalized Vegetation Index inversion to generate NPPa data set, and then calculated the PUE data set. Combined with climatical factors and PUE spatial grid sata, analysised NPPa and PUE spatial variation pattern and explored the universal mode of environmental response and their formation mechanism at the continental scale. Our result shown that the mean PUE value is about 0.15 to 0.07 g C m-2 mm-1, lower than the North and South America grasslands and higher than African grasslands and the spatial pattern has clear horizontal zone and vertical zone variation Law. We have found that the response of grassland vegetation type changing formed the universal Positive Skewness unimodal pattern of PUE and NPPa to MAP spatial variation at continental scale in the Eurasian grasslands. This study was the first to assess the mean PUE value, put forward universal mode of PUE and NPPa response MAP spatial variation, reveals the PUE spatial variation response environmental mode and potential mechanism, and also enhanced the understanding of the evolution of grasslands ecosystem and adaptive strategies to climate change.It can provide a reference for accurate assessment the productivity change of grassland ecosystems and their impact on climate change.

P1-R4

Determination of parameters for evergreen broadleaf forests in gross primary production capacity estimation algorithm using flux data for Amazon, Thailand and Australia

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Gross primary production (GPP) is the amount of carbon dioxide absorbed by plants via photosynthesis. It contributes to reveal carbon cycle to estimate GPP globally. Schmitt *et al.* (2009) estimates evergreen broadleaf forests occupy about 20% of the global forest area. It's important to take them into consideration when we estimate global GPP.

The amount of photosynthesis depends on photosynthetic capacity and reduction of photosynthesis results from weather conditions. Thanyapraneedkul *et al.* (2012) defines gross primary production capacity (GPPcapacity) as GPP without stress of dryness focusing on photosynthetic capacity and developed GPPcapacity estimation algorithm to estimate it using satellite data. In this algorithm, the relationship between ground-observed photosynthetically active radiation and GPPcapacity is drawn as the light-response curve of photosynthesis. The maximum value of GPPcapacity is considered to depend on chlorophyll content. Chlorophyll index (CI) is calculated using the reflectance of green and near infrared bands of satellite data as propounded Gitelson *et al.* (2003). The relationship between CI and GPPcapacity(2000) (i.e., GPPcapacity where photosynthetically active radiation is enough high value of 2000 $\mu molm^{-2}s^{-1}$) is assumed to be linear. Parameters in the light-response curve of photosynthesis and the linear regression are determined for each vegetation type in each climate region. Parameters for evergreen broadleaf forests have not been determined yet regardless of their importance when we estimate global GPPcapacity.

Parameters for tropical evergreen broadleaf forests were tried to be determined using flux data for Amazon (BR-Sa1 and BR-Sa3) and Thailand (TH-SKR) and MODIS surface reflectance data for the same flux sites. The data acquired in only dry season were used to examine the relationship between CI and GPPcapacity(2000) because those acquired in rainy season were affected by clouds. However, because of the narrow range of CI resulted from using the data for only dry season, the linear regression could not be determined. Wider range of CI is needed to determine parameters. Temperate evergreen broadleaf forests were considered to have a different range of it from tropical ones.

In this study, parameters common for tropical and temperate evergreen broadleaf forests were determined using the data for Australia (AU-Whr) together with those for Amazon and Thailand. The relationship between CI and GPPcapacity(2000) was examined (Fig.1). The ranges of them for Australia were smaller than tropical ones. A linear regression for an evergreen broadleaf forests group was determined as

$$\mathrm{GPPcapacity(2000)} = 0.121 \times \mathrm{CI} + 0.16\,. \quad (1)$$

They had a positive correlation with the correlation coefficient value of R=0.80.

GPPcapacity will be estimated for each flux site using the determined parameters and MODIS reflectance data. The values of GPPcapacity will be compared to both GPP and GPPcapacity values of flux data, and then validity of the determined parameters will be examined. Those results will be shown in our presentation.

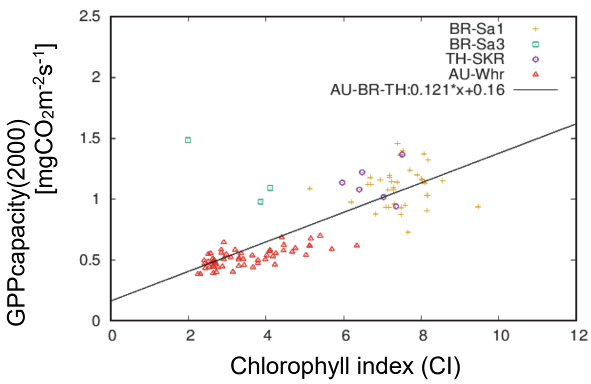

Fig.1. The relationship between chlorophyll index (CI) and GPPcapacity(2000) for Amazon (BR-Sa1 and BR-Sa3), Thailand (TH-SKR) and Australia (AU-Whr).

P1-R5

Long-term observation of the photochemical reflectance index (PRI) and light-use efficiency (LUE) in a temperate Japanese cypress forest at Kiryu Japan

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The light-use efficiency (LUE) of vegetation is one of the most essential parameters in production estimation models for terrestrial ecosystems. LUE generally expressed as the ratio of gross primary production (GPP) to absorbed photosynthetically active radiation (APAR). Due to the characteristic of photochemical reflectance index (PRI) which is sensitive to changes in carotenoid pigments (e.g. xanthophyll pigments) in live foliage, we recorded the canopy spectral reflectance data with hemispherical spectroradiometers to calculate the PRI. Then we sorted and analysis the diurnal, seasonal and interannual changes of PRI to try to figure out the LUE in temperate Japanese cypress forest. We measured and recorded the CO_2 flux data of canopy by using eddy covariance method. This can help us to calculate the GPP. We also recorded the micrometeorological data of temperate Japanese cypress forest such as temperature, wind speed and photosynthetically active radiation (PAR) since 2004.

During the monitoring period, clear seasonal and diurnal change of PRI were observed at temperate Japanese cypress forest. PRI was observed apparently changes with light intensity during clear days, but during cloudy days the PRI showed only fluctuated trend with light intensity. Furthermore, PRI was observed that high during July to December, and low during January to June. This phenomenon can attribute to the phenology effects. In conclusion, we found that the PRI can be a useful VI to detect the phenology related to gas-exchange in evergreen conifer forest.

Keywords: Japanese cypress, photochemical reflectance index (PRI), photosynthetic light use efficiency(LUE)

P1-R6

Detecting vegetation changes induced by afforestation and land use change in China using multiple satellite products

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Terrestrial vegetation environment in China has been changed under the influence of various anthropogenic factors, such as government-led greening and urbanization development on the broader area. Especially, afforestation and land use change are regarded as two of the most critical factors for those we have indicated above. Therefore, monitoring changes in forest cover in China are necessary to understand these impacts. Remote sensing data provide appropriate data with high spatial and temporal resolutions to better capture forest dynamics such as forest loss and gain across the regional, province, and national scale for China. In this study, we analyzed vegetation changes in China from 2000 to 2018 using multiple satellite-based data products. The satellite-based data includes various spatial resolution, from 25m (e.g., ALOS PALSAR and Landsat) to 1km scales (Terra, Aqua MODIS). Along with the Chinese National Forest Inventory report datasets, we assessed various satellite-based products and found that afforestation policy in China increases forest covers from 2000 to 2018 period.

P1-R7

Data Driven GPP and NEE Estimation with Lag Effect, Remote Sensing and Machine Learning

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Data-driven approach is effective for upscaling observation network data of terrestrial carbon fluxes. In this study, we estimated terrestrial gross primary productivity (GPP) and net ecosystem exchange (NEE) across the globe using machine learning methods – random forest regression (RF) and support vector regression (SVR) with MODIS collection 6 datasets after previous studies used collection 5 [e.g. Ichii et al. 2017; Tramontana et al. 2016; Kondo et al. 2015]. Furthermore, we introduced lag effects of input parameters (simply input as a new column) on GPP and NEE and this lag effect include either historical or future (lag within a month) remote sensing based input parameters. Because the ecosystem is a dynamic system, which current status is affected by historical factors and meanwhile will be observed in the future as some other physics or biochemical quantities. Thus, both processes may include the lag effect which mechanism are also different. Site-level experiments showed that the lagged parameter improved the accuracy of NEE estimation (R^2 0~0.06 increasing for total Koppen climate types). The lagged parameter worked well in site-level anomalies, particularly, lag effect by shortwave solar radiation or land surface temperature in the night. In order to interpret data-driven global GPP and NEE, we analyzed the input parameter pattern of each region (global, 11 regions), and extrapolation certainty. The estimated annual anomaly variations in GPP and NEE showed a good consistency with independent model-based estimations (TRENDY V6). In the future research, the lag-effected will be a more important factor for ecosystem's prediction and estimation.

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P1-R8

Changes in terrestrial carbon cycle in Mongolia: Synthesis analysis

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Mongolia is experiencing large changes in terrestrial environments due to recent climate changes (e.g. temperature rise and precipitation decreases) and enhanced human activities such as mineral extraction and land use changes. Therefore, monitoring of its environmental changes is important. So far, many studies analyzed terrestrial vegetation changes in Mongolia using satellite-based vegetation index, vegetation cover datasets, and ecosystem models. However, synthesis analysis using ground observation, remote sensing, and ecosystem modeling is missing.

We initiated a synthesis analysis using various existing datasets toward better understandings terrestrial carbon cycle and vegetation changes in Mongolia. Potential datasets include network of eddy-covariance observation, various remote sensing products, data-driven (machine-learning) estimates, process-based models, and top-down estimations. Target periods are 1980-present and 2000-present.

P1-R9

Using the BRDF corrected photochemical reflectance index to track light use efficiency for subtropical evergreen mixed forest

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Light use efficiency (LUE) is a key indicator of vegetation photosynthesis, it can provide important insights into how vegetation productivity responds to environmental conditions. Photochemical reflectance index (PRI) is based on the reflectance at 531 nm and 570 nm, which can reflect the process of xanthophyll cycle of plants under different radiation conditions. In this study, we used tower-based PRI and gross primary productivity (GPP) measurements to explore the ability of PRI to track LUE variations for a subtropical evergreen mixed forest in South China. The results show that a stronger relationship between bidirectional reflectance distribution function (BRDF) corrected PRI and LUE exists ($R^2_{origin} = 0.35$, $R^2_{corrected}$=0.51). Generally, PRI is able to capture diurnal and seasonal changes in LUE. Simultaneously, there was a significant correlation between LUE and PRI, but there was a large seasonal difference in its correlation. The correlation in winter was significantly stronger than that in summer. The strongest correlation is in November (R^2=0.83) and the weakest is in July (R^2=0.11). Photosynthetically active radiation (PAR) absorbed by vegetation had strong influence on LUE-PRI relationship, while vapor pressure deficit (VPD) and air temperature (T_a) had weak influence on LUE-PRI correlation. We used ground-based lidar to retrieve the vertical structure of forest crown, and found that the possibly complex vertical structure tend to have higher LUE. Overall, we found that the relationship between PRI and LUE is affected by the common effect of the environmental limitation and vegetation canopy structure.

P1-R10

Developing a Machine Learning based Flowering Detection and Quantification Algorithm using Time-Series Image Data

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Phenological phenomena of plants are deeply affected by climate change, therefore studies on phenology are rapidly increasing. To collect plant phenology data, digital repeat photography is widely used worldwide, generating massive image data. In response to demands for automatic processing of image big data, several analysis techniques have been developed. For several decades, it had been mainly focused in quantifying leaf phenology. Recently, however, there is growing interest in detecting the changes of flowering phenology. In this study, we utilized machine learning techniques to detect and quantify flowering phenology. For our training dataset preparation, we used downloaded images from ImageNet and Google Images. Due to the fact that white color is more sensitive to illumination changes and possess greater difficulty in processing the images, we focused on the species that only have white colored flowers. We manually annotated every image to the patches that contain flowers or only leaves. For testing the performance of the model, we also prepared several time-lapse videos that show discrete changes in phenological stages. Then, we implemented and trained a Mask Region-Convolutional Neural Network(Mask R-CNN) model. The model, pre-trained with MS COCO dataset, was re-trained with our own dataset and tested with the time-lapse videos. We performed quantification of changing flowering phenology by calculating the polygon area that model predicted as flowered white. The results were consistently successful in quantifying the changing flower phenology as the calculated area showed progressive growth and decline along with the phenological changes, while showing highest value at the peak flowering moment. The results and insights gained from our study will broaden the understanding of automatic quantification and detection of changes in flowering phenology.

P1-R11

Lidar-derived canopy structure of restored temperate wetlands

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California's Sacramento-San Joaquin Delta (Hereafter "Delta") is a region of immense significance in the Western USA. Historically, the Delta was a floodplain with very fertile soil, containing high levels of organic carbon and nitrogen. During the turn of the 20th century the Delta was levied and drained for agriculture, exposing its high carbon content peat soils to the air and enabling aerobic respiration of the native microorganisms. This has caused subsidence of up to seven or eight meters in some areas, causing significant stress on the surrounding network of levies. The Delta reroutes water to supply California's Central Valley irrigation project at the same time as it distributes drinking water to over 25 million people in the southern part of the State. If the Delta were to experience levy failure it would have severe human and material costs, measured in trillions of USD, with the potential to cripple the state for years or even decades.

Rehabilitating wetlands has been shown not only to halt subsidence caused by aerobic respiration, but also to lead to soil accretion due to the high productivity of the native wetland ecosystem and the decomposition of its litter. The aim of this study is to combine robust and continuous eddy-covariance measurements with high resolution LiDAR imagery to examine subsidence, canopy structure, and soil accretion rates across the Delta. I will source my data from the UC Berkeley Biomet Lab's Ameriflux Core sites, which compare intensive conventional agriculture to several different strategies of wetland rehabilitation. I plan to show that the wetland restoration efforts are effective over decadal and centurial timescales at not only sequestering carbon from the atmosphere, but also at restoring the region's soil reserves and protecting a key component of California's water redistribution network.

P1-M1

Estimation of greenhouse gas budget over high-latitude ecosystems using a process-based ecosystem model, VISIT

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High-latitude warming has increased greenhouse gas emissions from northern ecosystems, resulting in a positive feedback on the climate system. Process-based ecosystem models have been used to estimate high-latitude carbon dioxide (CO_2) and methane (CH_4) fluxes and budgets. These estimates are characterized by large uncertainties. In this study, we simulated CO_2 and CH_4 fluxes across high-latitude ecosystems using a process-based terrestrial ecosystem model, VISIT (Ito and Inatomi, 2012). The model was calibrated using 17 multi-year eddy covariance data set from cool temperate, boreal, and arctic research sites (71-site years). In high-latitude ecosystems, the nitrogen availability strongly limits carbon assimilation; thus we implemented a carbon and nitrogen coupling scheme into the model. In addition, we introduced a soil heat conduction component into VISIT to be better represent soil thawing-freezing processes. Water table depth was simulated by a water balance model optimized through observations. Six parameters of VISIT were optimized using CO_2 and CH_4 fluxes at the high-latitude ecosystems, including fen, bog, lowland forest, and tundra sites. We classified the observation sites into four categories (peatland, forested peatland, dry tundra and wet tundra), and optimized model parameters for each category. The differential evolution method, a global search algorithm for parameters, was used to optimize the model parameters. As a cost function, the Nash-Sutcliffe model efficiency coefficient was maximized. We used the best model parameters for estimating the CO_2 and CH_4 budgets across the terrestrial wetlands north of 40°N.

As a result of the parameter optimization, we successfully improved CO_2 and CH_4 fluxes by VISIT model. The seasonal variations in the CH_4 fluxes were improved by introducing the soil heat conduction model, especially for the high-latitude ecosystems. In the presentation, we apply the model simulation over the Pan-Arctic and boreal regions for estimating CO_2 and CH_4 budgets. Then, we discuss the accuracy of the regional estimates by comparing with the inverse estimates from previous studies. We discuss the importance of the tower flux data for improving model performance and reducing uncertainties, and the importance of collaborations among field scientists and ecosystem modelers.

Reference

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P1-M2

Latent heat and sensible heat flux simulation in tropical peat swamp forest using artificial neural network

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Tropical peat swamp forests play an important role in the global climate system as they are known to be one of the substantial regulators to the atmospheric carbon, water, and energy exchange. Two major components of energy exchange between the land surface and atmosphere are the latent heat (LE) and sensible heat (H) flux. LE and H can be measured using various techniques, including eddy covariance technique. LE and H strongly influence the local climate such as its temperature, soil moisture and precipitation via heat exchanges between the surface and atmosphere. In general, measurements of LE and H using eddy covariance are done by deploying a 3-D sonic anemometer and an open-path gas analyzer. Such instrumentations can be costly. However, recently, the estimation of LE and H through computer simulation are becoming more cost efficient and reliable.

The objective of this study is to evaluate the applicability of artificial neural network (ANN) in simulating LE and H for a tropical peat swamp forest. In this study, an artificial neural network (ANN), namely the gated recurrent unit (GRU) was developed and trained to simulate the LE and H. GRU was used because it performs well for sequential data and time efficient when learning over long term time series data. Development of the GRU was done using Python Keras library with a TensorFlow backend. Training of the GRU and validation of its output was done using eddy covariance data of LE and H measured from a tropical peat swamp forest in Maludam National Park (MLM), Sarawak, Malaysia which has been operational since 2011. Instrumentations setup for the site can be found in Tang *et al.* (2018).

P1-M3

Flood risk assessment in Bangladesh, India and Myanmar based on the AHP weight method and entropy weight method

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The climates of Bangladesh, India and Myanmar (BIM) region are subtropical and tropical monsoon climate. Floods frequently occur around here. Assessing the flood risk in BIM region is important for the safety construction of the BCIM-EC. According to the theory of flood disaster system, we selected evaluation indexes based on the synthetic analysis of hazard, sensibility and vulnerability. Using datasets of precipitation from 1980 to 2016, river network, DEM, land use, soil, vegetation coverage, population, GDP and et al, we established the risk assessment index system. To overcome the limitations of simple weighting method, We obtained the synthesized weight using the Analytic Hierarchy Process (AHP) method and the Entropy weight method. Each indicator was combined to obtain the final flood risk map. Based on the assessed results, about 0.09% and 5.85% of the BIM region have high risk and moderate to high risk. High risk and moderate to high risk zones in the BIM region were primarily concentrated on the Ganges Plain in northern India, Assam State in northeastern India and most of Bangladesh. Bangladesh is the country with the highest risk among three countries. The results show that high risk areas and moderate to high risk areas take up 2.23 and 44.14% of the total area of the Bangladesh, respectively.

Keywords: flood hazard; risk assessment; AHP; the entropy weight method; the BCIM-EC

P1-M4

Freezing injuries impact carbon and water use efficiency by leaf area index of natural zonal terrestrial vegetations in Inner Mongolia between 2004 and 2015

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Cycle of vegetation, which are associated with canopy structure (i.e. leaf area index). These traits of vegetation are strongly influenced by freezing injuries. The impacts of freezing injuries on CUE and WUE differ among injury types and vegetation types. In Inner Mongolia, freezing injuries of high occurrence include Frost, Cool and Cold, while natural zonal terrestrial vegetations contain broadleaf forest, needleleaf forest, scrub, steppe and desert steppe. In this study, annual LAI_{max}, CUE and WUE series between 2004 and 2015 were integrated from MODIS LAI, GPP, NPP and ET of 8-day. Also, indice dataset of each injury was spatialized to the scope of Inner Mongolia after calculation from daily site meteorological records. Linear trend and coefficient analysis were also employed to reflect the correlations between these variables. The results showed that frost and cool are the dominant freezing injuries for CUE, while cold and heavy cold are the dominant freezing injuries for WUE. LAI_{max} is restrained by all freezing injuries in mostly vegetations, while it is constrained by cold in steppe and desert steppe. This impact decreased CUE and WUE of grassland immediately due to the positive correlation between LAI_{max} and CUE/WUE. However, in forests, freezing injuries increased CUE for the losses of photosynthetic biomass through cool and cold, while stimulated CUE for boosted physiological activity through frost and heavy cold. On the other hand, WUE in forests are stimulated by reduced LAI_{max}, which can be explained by tender biome and more tillers after freezing injuries.

Figures:

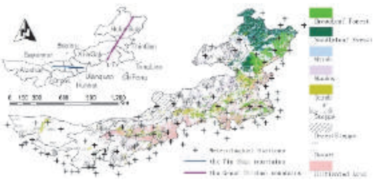

Fig.1 The sketch map of this study

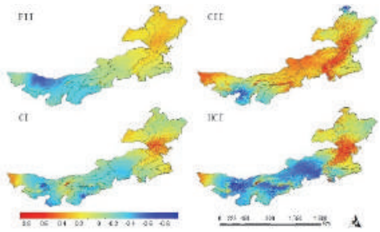

Fig.2 The spatial variation slope of frost, cool, cold and heavy cold

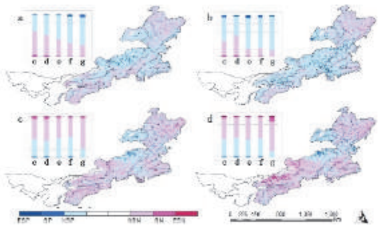

Fig.3 The temporal correlations between FIIs and LAI_{max}

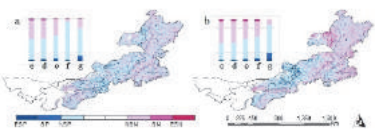

Fig. 4 The temporal correlations of LAImax to CUE and WUE

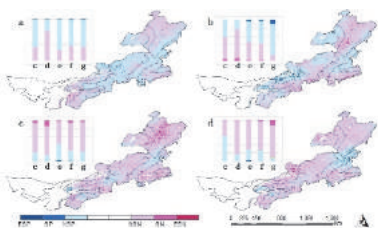

Fig.5 The temporal correlations of FIIs to CUE

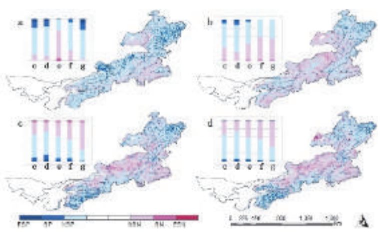

Fig.6 The temporal correlations of FIIs to WUE

Note: Fig. a, b, c, d represent the correlations of frost, cool ,cold and heavy cold separately. In every histogram, pilliar c, d, e, f, g represent the pixel ratio of BLF, NLF, Scrub, steppe and desert steppe separately.

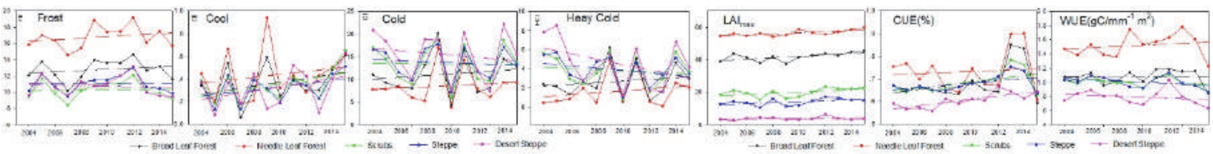

Fig.7 the temporal dynamics of freezing injuries, LAImax, CUE and WUE of each zonal terrestrial ecosystem in Inner Mongolia

P1-O1

Field-scale productivity and water use of a high-yielding rice cultivar

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Rice production for industrial uses (animal feeding and food processing) has recently been increasing. High-yielding rice varieties, such as Oonari and Takanari, are often used for industrial rice production. Studies based on pot experiments or experimental fields have shown that high-yielding rice varieties differ from common Japonica varieties such as Koshihikari in various aspects of physiology and phenology (Taylaran et al. 2011; Chen et al. 2014; Ikawa et al. 2019). However, less known is how the varieties behave in a real crop field.

Our early study based on a bottom-up approach using leaf measurements and a canopy model demonstrated that the difference in evapotranspiration between Takanari and a common rice cultivar, Koshihikari strongly depends on wind speeds in the natural field (Ikawa et al. 2018). However, a modeling approach has a limitation in accounting for ecophysiological properties of rice plants that considerably change over the course of the crop growth (Ono et al. 2013). Continuous field-scale measurements therefore are desirable to quantitatively evaluate productivity and water use of a high-yielding rice cultivar throughout the growing season.

The objectives of this study are to measure CO_2 and energy fluxes by eddy covariance in a rice field of a high-yielding rice cultivar, Oonari over two growing seasons at the Ryugasaki site (RGS) and to compare them with those measured in a typical rice field (Mase site, MSE) with a common rice cultivar (Koshihikari) in the Kanto area of Japan. By so doing we aim to answer following questions:

- Does a high-yielding rice cultivar, Oonari show a higher productivity (photosynthesis) and water use (evapotranspiration) than a common rice cultivar, Koshihikari as predicted by a model-simulation?
- How do the differences in photosynthesis and evapotranspiration between the varieties change by the growth stage and environmental conditions, such as wind speeds?

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P1-O2

Field challenges of eddy covariance measurement in tropical peat ecosystems in Sarawak, Malaysia – The TROPI experience

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In 2010, the Tropical Peat Research Laboratory Unit (now Sarawak Tropical Peat Research Institute) constructed three eddy covariance (EC) towers at three different tropical peatland ecosystems, namely an undrained peat swamp forest (UF), a relatively disturbed secondary peat swamp forest (DF) and an oil palm plantation (OP). The objective of these EC towers was to quantify the magnitude of greenhouse gases (GHGs) flux over a continuous period. TROPI was fully engaged with the management of the experimental sites in terms of maintenance and repairs, despite the various difficulties the research team had to face while working in a tropical peat environment. This paper describes the field challenges that TROPI researchers encountered throughout their commitment to ensure the collection of reliable data.

All three sites were beyond the reach of efficient road system. The UF, for instance, requires 30-minutes boat ride and 4.5 km trek through the jungle before reaching the site. Wildlife could pose a danger to the research team while at the site and cause some problems to the equipment at the experimental site. At DF site, the research team once found a mangrove cat snake (*Boiga dendrophila*) hiding in the canvas where the gas cylinders for calibration were kept. Since all three sites were isolated from consumer's power grid, the instruments utilize 12V solar power supply. The rated output at 1 kW was sufficient to keep the system operating throughout the day, until a drastic attenuation was detected in May 2015. This caused the system to shut down at night when the batteries were discharging abnormally. The batteries had to be changed and intense labor were required for the replacement of the batteries which weighed at least 65 kg.

Since the beginning of the measurements at the tower sites, TROPI researches have overcome many obstacles in carrying out their field tasks. Such experiences could be a sound guidance which may contribute to further improvements in the future. Inevitable situation may unfold but proper planning and preventive maintenance should help to enable safe field work conditions and the collection of continuous good quality data.

Abstracts: Poster Presentations (day 3)

P2-F1

Net ecosystem CH_4 exchange of three tropical peat ecosystems in Sarawak, Malaysia

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Wetlands of Southeast Asia are thought to be one of the greatest sources of methane (CH_4) to the atmosphere. Tropical peatlands are typical in Southeast Asia, widely distributed in Malaysia and Indonesia. Despite the huge carbon stocks in these ecosystems, data on net ecosystem exchange of CH_4 (F_{CH4}) fluxes are very limited. A few studies of soil CH_4 flux have reported that CH_4 emissions from tropical peat swamp ecosystems were negligible. On the other hand, recently, it was reported that some tree species growing in peat swamp forest emit considerable CH_4 from their stems. Thus, measurement of F_{CH4} is essential to quantify the CH_4 balance of tropical peat ecosystems. To our knowledge, only three studies have measured the F_{CH4} from tropical peat swamp forest.

In this study, we measured F_{CH4} continuously above three different tropical peat ecosystems in Sarawak, Malaysia using the eddy covariance technique from February 2014 to January 2017 (3 years). The three sites were different in disturbance; namely an undrained peat swamp forest (UF), a relatively disturbed secondary peat swamp forest (DF) and an oil palm plantation (OP) established on peat. This is the first eddy covariance measurement of CH_4 flux in an oil palm plantation. Our objectives were to: (1) quantify the F_{CH4} of each site; (2) examine the response of F_{CH4} to groundwater level (GWL); and (3) compare F_{CH4} among the three ecosystems and discuss the inter-site difference of CH_4 balance.

The F_{CH4} was determined half-hourly as the sum of eddy CH_4 flux and CH_4 storage change in an air column below the flux measurement height. Monthly mean F_{CH4} was always positive, even in the drained OP. The daily mean F_{CH4} was positively correlated to GWL in UF and DF, in which GWL controlled the production and oxidation of CH_4 in peat. In contrast, the F_{CH4} was almost independent of GWL in OP; the GWL was lowered by drainage. The annual CH_4 emission was significantly different among the sites. The inter-site difference was explained by a significant positive exponential relationship with GWL. This positive relationship suggests that the conversion of a peat swamp forest to an oil palm plantation decreases CH_4 emissions, because the land conversion accompanies drainage. The F_{CH4} from UF was lower than those from mid-latitude peat ecosystems, though it was much higher than soil CH_4 emissions measured by the chamber technique in tropical peat swamp forests.

P2-F2

Biophysical controls on the variability of ecosystem-scale CO_2 exchange in a Bornean peat forest

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Tropical peat forests are a globally important reservoir of carbon, but little is known about CO_2 exchange on an annual basis as interannual ecosystem-scale measurements of undisturbed tropical peat forests have not been measured to date. We used the eddy covariance technique to measure the net ecosystem exchange of CO_2 (NEE) between the atmosphere and an undisturbed tropical peat forest in Sarawak, Malaysia over four years from 2011 to 2014. The aim of this paper is to improve the state of current knowledge of tropical peat forests with respect to the seasonal and interannual variability in NEE and its components, gross primary productivity (GPP) and ecosystem respiration (RE), and the role played by environmental factors including changes in atmospheric radiation and ozone that may result from fires elsewhere in Southeast Asia in controlling CO_2 exchange. Our results demonstrated that the forest was a net source of CO_2 to the atmosphere during every year of measurement, similar to a hydrologically disturbed tropical peat forest in Central Kalimantan, Indonesian Borneo. The ecosystem became a sink for CO_2 during the rainy season relative to the dry season during 2011, but the converse held for the subsequent three years. The inter-annual variation in NEE was largely modulated by the variation in gross primary production (GPP), which was jointly controlled by vapor pressure deficit (VPD) and photosynthetically active photon flux density (PPFD). Temporal changes in ecosystem respiration (RE) were closely related to water table depth. Patterns of diffuse radiation and ozone played a minor role in controlling the variability of NEE and its components. Results suggest that potential future increases in VPD may result in additional net CO_2 losses from this undisturbed tropical peat swamp forest in the absence of plant acclimation to such changes in atmospheric dryness. These data will ultimately improve land-surface parameterizations for models used to estimate the regional and global C budgets and to predict ecosystem responses to global climate change. Such results can also contribute to global CO_2 mitigation efforts.

P2-F3

Evapotranspiration from three tropical peat ecosystems in Sarawak, Malaysia

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Tropical peatlands in Southeast Asia are mostly found in Malaysia and Indonesia, storing an enormous amount of soil organic carbon as peat. In last decades, however, the peatlands have been drained for industrial agriculture development. This development has significantly changed the peatland ecosystem conditions especially the pedo-hydrological condition. Groundwater level is one of the most important factors controlling the oxidative peat decomposition in peatlands. Evapotranspiration (ET) is generally a major determinant of groundwater level of peatlands and thus a key process linking the water cycle with carbon cycle. Understanding the nature of ET from different ecosystems has been an ongoing effort in global water cycle.

Tropical vegetation plays a major role in atmospheric circulation, which drives the regional and global climate systems by massive ET and its resultant strong evaporative cooling. Currently, the data of ET from tropical peatland is very limited in comparison with mid-latitude peatlands. Thus, in this study, we measured the ET for 8 years (January 2011 to December 2018) in three tropical peatland ecosystems in Sarawak, Malaysia using the eddy covariance technique. The objectives of this study were (1) to quantify the ET, (2) to examine the seasonal pattern of ET and (3) to determine the underlying environmental factors that influence the ET. Mean annual long-term precipitations at the UF, DF and OP were 3201 ± 614, 3358 ± 465 and 2797 ± 224 mm year^{-1} (mean ± 1 standard deviation), respectively. The mean annual long-term air temperature was 26.5 ± 0.2 °C. The ET was determined half-hourly and summed up annually after gap filling.

P2-F4

Patterns and controls of light use efficiency in four contrasting forest ecosystems in Yunnan, Southwest China

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Ecosystem light use efficiency (LUE) is a critical parameter in estimating CO_2 uptake by vegetation from climatological and satellite data. However, the spatiotemporal dynamics and biophysical regulations of ecosystem-level LUE are not well understood, resulting in large uncertainties in the estimation of gross primary productivity (GPP) using LUE-based models. In this study, we used eddy covariance (EC) to explore spatiotemporal variations and controls of LUE in four contrasting forest ecosystems (savanna, tropical rainforest, subtropical evergreen forest, and subalpine coniferous forest). Based on 27 site-years of data, we found that 1) the multiyear mean LUE was 0.063, 0.251, 0.247, and 0.140 g C · mol photon^{-1} in the four contrasting ecosystems; 2) the LUE in the wet season (May-October) was higher than that in the dry season in all studied ecosystems; 3) the leaf area index (LAI) controlled GPP and LUE significantly and explained 74%, 29%, 54%, and 36% of the variation in GPP and 51%, 19%, 41%, and 54% of the variation in LUE in the four contrasting ecosystems; 4) path analysis revealed the critical roles of GPP and vapor pressure deficit (VPD) in controlling LUE in these four forest ecosystems; and 5) under warming scenarios, LUE may decrease in savanna but increase in the other three ecosystems, while decreasing precipitation (P) may reduce LUE in the ecosystems studied. This study improves our understanding of the influence of biophysical factors on LUE and demonstrates how LUE changes with variations in temperature, soil moisture and LAI, thereby improving estimations of large-scale carbon exchange/cycling.

Keywords: Ecosystem light use efficiency, Critical factors, Path analysis, Climate change, Forest ecosystems, Eddy covariance

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P2-F5

The forest-atmosphere carbon dioxide and methane exchanges in Indian tropical mangrove ecosystem

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Mangrove ecosystems play a major role in the global carbon cycle. Since, the mangrove ecosystems are extremely productive and have the three different compartments namely, aboveground and below ground biomass and aquatic system. However, there is a gap in the understanding of Greenhouse gases (GHGs) exchange between forest canopies to atmosphere (CO_2, CH_4 flux) in Indian mangroves. We for the first time estimate the forest CO_2 net ecosystem exchange (NEE) and CH_4 flux at Pichavaram mangrove, south east coast of India, using the eddy covariance method during October 2017 to June 2019. The maximum daytime NEE varied from -14 µmol m^{-2} s^{-1} in the month of January 2019 to –5 µmol m^{-2} s^{-1} during the summer month of April 2018. The estimated annual gross primary production (GPP) was 1466 g C m^{-2} y^{-1} and 1595 g C m^{-2} y^{-1}, Ecosystem respiration (R_{eco}) was 1283 g C m^{-2} y^{-1} and 1401 g C m^{-2} y^{-1}, during the period of October 2017- September 2018 and October 2018- June 2019, respectively. The mangrove forest appeared to be a modest sink of atmospheric CO_2, with an annual average Net Ecosystem Productivity (NEP) of 183 g C m^{-2} y^{-1} (October 2017- September 2018) and 193 g C m^{-2} y^{-1} (October 2018- June 2019), whereas during the summer periods it acted as a source. Particularly in the summer months of June to July 2018 and April to June 2019 the ecosystem acted as a net carbon source with the monthly averaged values being -0.54, -0.26, -0.46, -0.79 and -1.1 g C $m^{-2}d^{-1}$ respectively. The estimated annual evapotranspiration (ET) during the study period was 609 mm y^{-1}, whereas the precipitation was 653 mm y^{-1} (much dryer than the long-term average). The surface energy balance of about 61% of the available energy was accounted. The mean concentration of CH_4 emission was 2142± 256 ppb or 1.513 mg m^{-3}. The maximum methane concentration of 3606 ppb was in August 2016. Minimum of 1,820 ppb was recorded during May 2017. The monthly mean CH_4 flux ranges from -2.27 to 9.91 nmol m^{-2} s^{-1} at the site. The methane at the Pichavaram forest is characterized by high concentration but very low fluxes compared to similar other environments. The preliminary result concludes that, the mangrove forest seems to be a sink and sources of CO_2 and CH_4 to atmosphere, respectively. However, it is noteworthy that the carbon sink capability may decline in the future under rising temperatures, decreasing rainfall pattern, variable in salinity and changes in tidal inundation patterns.

Keywords: Pichavaram Mangroves; Carbon exchange, Methane flux; energy flux; Eddy Covariance.

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P2-F6

Ecological effect of fog on carbon and water exchanges in tropical rainforest and sub-tropical evergreen forest, Southwest China

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The Southwest region of China is rich in biodiversity and ecologically sensitive zone, so its receives considerable research attention. However, for the past several decades anthropogenic activities and climate change have posed a series of serious threats to tropical rainforest and sub-tropical forest ecosystems, Southwest China. Generally these forests are frequently immersed with fog occurrence. Ultimately it's helps increasing the soil water availability through leaf interception, reducing atmospheric water demand by frequent leaf wetting and reduces evapotranspiration. At the same time fog affects light availability and increases the diffuse fraction, limiting forests primary productivity. In recent years, fog frequency and duration has been reducing due to the land use changes and seasonal droughts of the region. Therefore, it is critical to understanding the fog dynamics in tropical seasonal rainforest (Xishuangbanna) and subtropical evergreen forest (Ailao Mountain).

The present study results from the meterological and eddy covariance (EC) based flux measurements carried out over these forests. The tropical rainforest and subtropical evergreen forest, estimated interannual gross primary production (GPP) was 25.47 t C ha^{-1} yr^{-1} and 20.68 t C ha^{-1} yr^{-1}, Ecosystem respiration (R_{eco}) was 24.22 t C ha^{-1} yr^{-1} and 13.66 t C ha^{-1} yr^{-1}, respectively. These forests appeared to be a sink of atmospheric CO_2, with an inter annual average variability of Net Ecosystem Productivity (NEP) of 1.25 t C ha^{-1} yr^{-1} (Xishuangbanna) and 7.02 t C ha^{-1} yr^{-1} (Ailao Mountain). The visibility was measured by PWS 100 (Campbell Scientific Inc., Logan, UT, USA) in this forest. The fog deposition occurs frequently in the whole year in sub-tropical evergreen forest, higher density occurred during the wet season. Whereas in the tropical rainforest ecosystem fog occurred during the dry season, which helps the plant community by nutrient deposition as well as increase the soil water availability through leaf interception. Further on this research, we recently installed the Fog monitor-Droplets (model FM-120-Boulder, Colorado, USA) over these forest ecosystems on top of the EC flux tower to understanding the number and size of the fog droplets and density. We are also collecting the fog water using the active strand fog collector on top of the towers to study the fog water chemistry. Further we will investigate the relative contribution of fog water inputs to forests ecosystem through sap flow techniques and stable isotopic signature in different sources from fog, rain, plant transpired and soil waters. Finally this study will concludes the eddy covariance based evapotranspiration and water use efficiency rate during foggy and non-foggy conditions of the forests.

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P2-F7

Estimation of surface carbon dioxide exchange over rubber tree plantation in Thailand using area-averaged flux method

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Thailand has approximately 3 million hectares of latex-producing natural rubber plantations. These rubber plantations have a large potential to sequester atmospheric carbon into the biomass and soil. We applied the area-averaged flux method to evaluate the CO_2 flux over rubber plantation in Thailand. This method indicated a carbon sink over rubber plantation in 2017 by using CO_2 flux data from 3 rubber plantation with different age (south, east, and northeast of Thailand). These data were composed into a time series of the area-averaged surface flux by normalizing and averaging over a daily basis. Such composite fluxes could be determined for about 80% of the whole measurement time. The averaged Carbon absorption of rubber plantation in Thailand for 2017 was 71.9 T CO_2 ha $^{-1}$ year^{-1} and the daily average absorption was the highest in summer.

P2-F8

Latest in flux data analysis software: from quality control and gap filling to flux and footprint partitioning

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Over 500 flux towers are presently operational as a part of several dozen continental and national flux networks under the umbrella of the FluxNet global network. In addition, multiple dozens of flux towers operate as smaller dedicated networks and standalone projects.

In 2016-2018, new tools to collect, process, and share time-synchronized flux data from multiple towers were developed and deployed globally [1]. These new tools can be effective in fostering scientific interactions and collaborations among the multiple research communities:

- The fully automated FluxSuite system combines hardware, software and web services, and does not require an expert to run it.
- The system can be incorporated into a new flux station or added to a present station, using a weatherized remotely-accessible microcomputer, SmartFlux3.
- It utilizes EddyPro software to calculate fully-processed fluxes in near-real-time, alongside radiation, weather and soil data.
- All data are merged into a single quality-controlled file timed using PTP time protocol.
- Multiple stations can be linked into the time-synchronized network with automated real-time reports and email alerts.
- Flux researchers can cross-share station access to specific stations and data with each other.
- Remote sensing researchers and modelers without actual physical stations can form “virtual networks” of actual stations by collaborating with tower PIs from different physical networks.

The latest 2018-2019 development in this overall approach is the flux data analysis software, Tovi. Driven and guided by the research community, and developed, implemented and supported by LI-COR Biosciences, it is designed to seamlessly ingest the data from the flux stations and to allow a non-micrometeorologist to quality control and analyze the data:

- Shareable, traceable, and reproducible parallel workflows use methods available from the research community, and greatly enhance standardization and comparability among sites and users, making results defensible.
- The present set of tools allows rapid execution of the QC/QA and data analysis steps which have been quite time-consuming and complicated in the past, and other data analysis steps virtually not doable in the past, all using interactive and intuitive GUI.
- Examples include an automated search of 14000+ weather stations data for gap-filling; site-specific u* thresholds; advanced footprint calculations and flux apportioning; NEE and ET flux partitioning; automated generation of reproducible workflows and specific lists of references for each workflow; etc.

This presentation will show how this latest tool can be used for a sophisticated QC/QA and data analysis, and will describe how the overall approach can be utilized for facilitating collaborations across research domains to improve scientific interactions and promote joint project developments, grant writing, and other forms of collaboration, between the flux, remote sensing and modeling communities.

[1] Burba et al, 2018. Time- and Space-Synchronized Flux, Weather, Soil and Optical Sensor Networks. 3d International GHG Flux Workshop “From Leaf, Soil and Canopy to Remote Sensing and Modelling”, Nanjing University of Information Science & Technology, China, October 22-25

P2-F9

Illustrative maps of past and present eddy covariance measurement locations: II. high-resolution images

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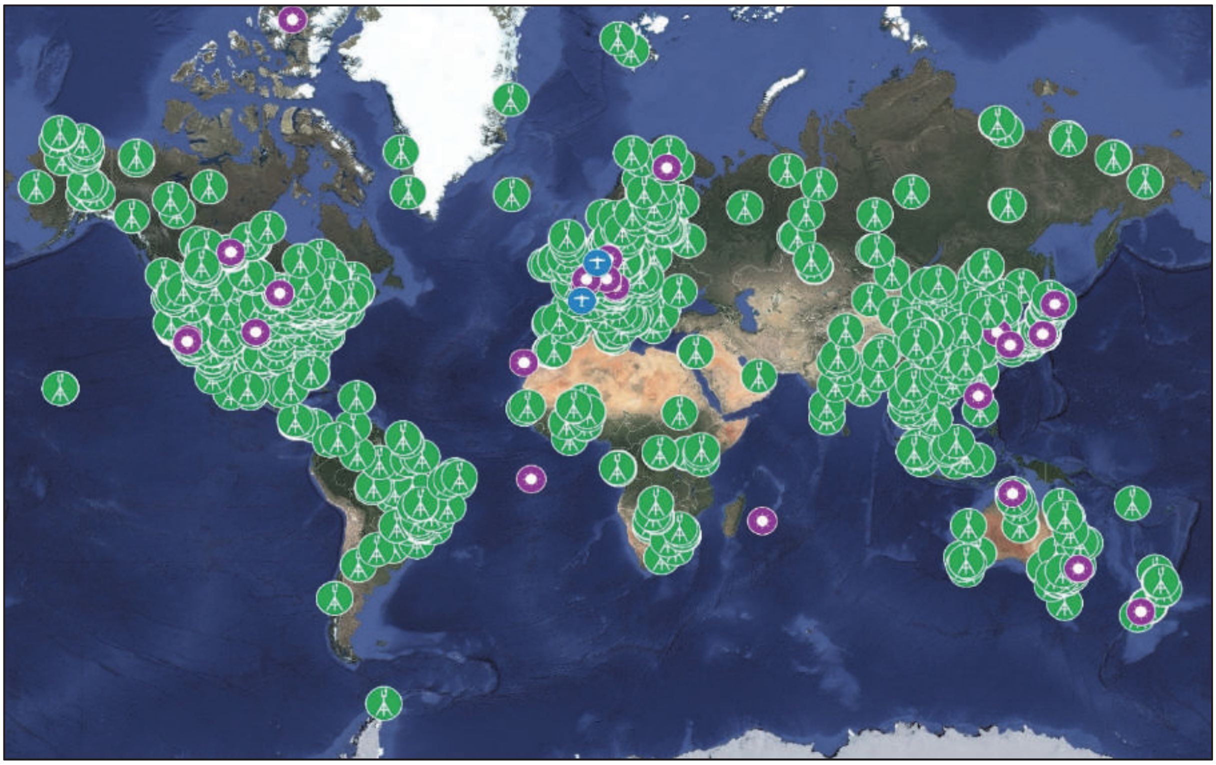
The goal of this presentation is to provide high-resolution images of maps with locations where eddy covariance flux measurements have been done in the past and where they are being done now. This includes large networks which already have done detailed inventories, compiled databases and designed very engaging interactive maps, but also smaller networks, tower clusters and individual site, including all long-term stationary site locations, all short-term campaign locations, as well as all mobile transects over land and ocean.



The images show locations of all past and present eddy covariance measurements available on the latest date of update, a total of 2126 stationary measurement locations and 2 airborne campaigns with 27 flight tracks. The exactly overlapping sites (e.g., with identical coordinates) have been removed except for cases where a group indicated that several eddy covariance levels or closely positioned towers were deployed.

It is likely that some of the locations with multiple systems have been removed in this process artificially reducing the count. There is also a possibility that some sites were listed at slightly different locations due to different coordinate rounding at different databases artificially increasing the count.

In addition to the reduction in the count due to missing information about multiple levels or closely clustered sites, there is still a significant amount of missing measurement locations related to: (i) evapotranspiration measurements and related networks; (ii) urban GHG flux measurements; (iii) shipborne and airborne transects from the flux measurements

Thank you very much to all who contributed to this short, yet hopefully useful effort, especially the following organisations: FluxNet, Ameriflux, Asiaflux, CarboEurope, ChinaFlux, ICOS, KiwiFlux, OzFlux; and numerous individual groups and people for their past and future contributions.

P2-F10

Spectroscopic Effects in Laser-based Eddy Covariance Flux Measurements

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A significant portion of the production and consumption of trace gases (e.g. CO_2, CH_4, N_2O, NH_3, etc.) occurs in areas without sufficient infrastructure or easily available grid power to run traditional closed-path flux stations. Open-path analyzer design allows such measurements with power consumption 10-150 times below present closed-path technologies, helping to considerably expand the global coverage and improve the estimates of gas emissions and budgets, informing the remote sensing and modeling communities and policy decisions, all the way to IPCC reports. Broad-band NDIR devices have been used for open-path CO_2 and H_2O measurements since the late 1970s, but since recently, a growing number of new narrow-band laser-based instruments are being rapidly developed.

The new design comes with its own challenges, specifically: (i) mirror contamination, and (ii) uncontrolled air temperature, pressure and humidity, affecting both the gas density and the laser spectroscopy of the measurements. While the contamination can be addressed via automated cleaning, and density effects can be addressed via the Webb-Pearman-Leuning approach, the spectroscopic effects of the in-situ temperature, pressure and humidity fluctuations on laser-measured densities remain a standing methodological question.

Here we propose a concept accounting for such effects in the same manner as Webb et al. (1980) proposed to account for respective density effects. Derivations are provided for a general case of flux of any gas, examined using a specific example of CH_4 fluxes from a commercially available analyzer, and then tested using "zero-flux" experiment.

The proposed approach helps reduce errors in open-path, enclosed, and temperature- or pressure-uncontrolled closed-path laser-based flux measurements due to the spectroscopic effects from few percent to multiple folds, leading to methodological advancement and geographical expansion of the use of such systems providing reliable and consistent results for process-level studies, remote sensing and Earth modeling applications, and GHG policy decisions.

H	LE	WPL Terms		Spectroscopic Effects				
		WPLH	WPLLE	Temperature	Water Vapor	Contribution to final flux value		
W m^{-2}	W m^{-2}	mg m^{-2} h^{-1}	mg m^{-2} h^{-1}	mg m^{-2} h^{-1}	mg m^{-2} h^{-1}	mg m^{-2} h^{-1}	umol m^{-2} s^{-1}	% of flux*
0	0	0.00	0.00	0.00	0.00	0.00	0.000	0
50	50	0.61	0.13	0.19	0.05	0.24	0.004	8
50	400	0.61	1.03	0.19	0.42	0.61	0.011	20
200	50	2.46	0.13	0.76	0.05	0.81	0.014	27
200	400	2.46	1.03	0.76	0.42	1.18	0.021	39
400	50	4.92	0.13	1.52	0.05	1.58	0.027	53
400	400	4.92	1.03	1.52	0.42	1.94	0.034	65

Example contributions of WPL terms, WPLH (thermal expansion term) and WPLLE (water vapor dilution term), and related spectroscopic terms (temperature and water vapor), to the CH_4 fluxes from an existing laser-based open-path high-speed CH_4 gas analyzer at standard ambient conditions[1] at different levels of sensible (H) and latent (LE) heat fluxes.

P2-F11

Factors influencing the variation of CO_2 flux and evapotranspiration in larch forest ecosystem affected by the extreme wet-soil condition

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This study investigated the CO_2 exchange from 2005 to 2014 inside and above a larch-dominant forest in the central Lena river basin, eastern Siberia. A wet-soil condition, such as that found in the active layer (seasonally thawed soil layer of upper permafrost), containing unusually high soil water close to saturation and partial surface waterlogging, was prolonged during the warm season from 2005 to 2009. In later years, the soil layer closer to the ground surface became dry (~10% volumetric water content), although the deeper part remained relatively wet (~30%). We quantitatively compared the whole forest and the understory CO_2 exchanges to detect the separate effects of excessive soil waters on the overstory and understory vegetation. Comparison of the fitting parameters of the light response function at two levels revealed a smaller maximum net ecosystem exchange (NEE) under light saturation with a steep response under weak light conditions for the understory. The CO_2 exchanges at the understory increased from the wet-soil period to the drying soil period by 46% (1.3 g C m^{-2} d^{-1}) of gross primary production (GPP) and 29% (1.2 g C m^{-2} d^{-1}) of ecosystem respiration (ER), while no trend was found in the ecosystem scale fluxes. These increases were due to an increasing understory biomass, changes in plentiful light and soil water in the inside-canopy environments, and enhanced turbulent mixing. The decline in the larch contribution could be compensated for by the understory growth and the remaining wetness of the active layer, which indicated that the interactions between the larch and the understory supported the stability of carbon cycles in this forest ecosystem.

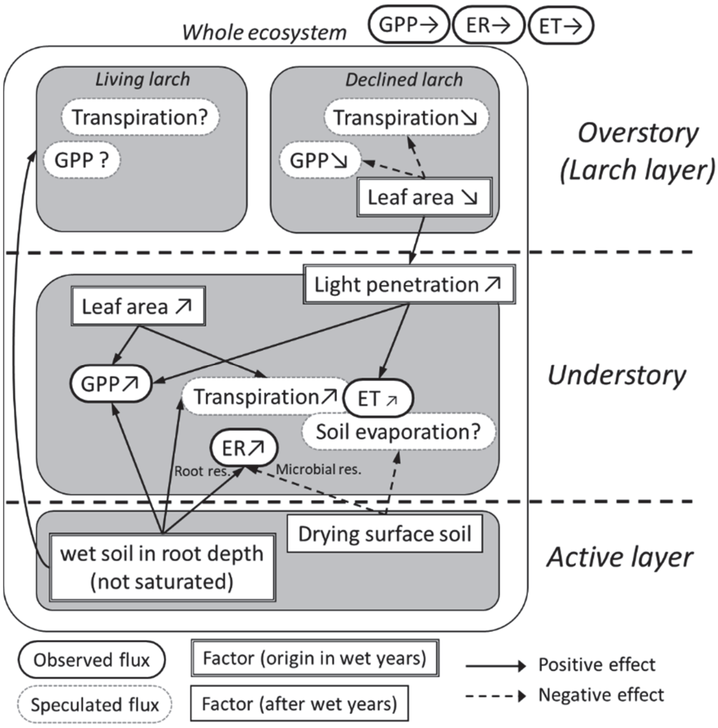

Figure 1. Factors influencing the variation of CO_2 flux and evapotranspiration in larch forest ecosystem affected by the extreme wet-soil condition. Arrows to the right of variable names indicate changes after the wet-soil period: increase (diagonal upward), decrease (diagonal downward), and insignificant change (horizontal). (Kotani et al., 2019, Agric. For. Meteorol., 265, 295–309.)

P2-F12

Twenty years of carbon monitoring at Sapporo forest meteorology research site in the northern part of Japan

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Sapporo forest meteorology research site (AsiaFlux site code: SAP) is located in Hokkaido, the northern part of Japan (42°59‘N, 141°23’E, elevation 180m). It is a broadleaf deciduous forest with white birch (*Betula platyphylla*), japanese oak (*Quercus crispula*) and dwarf bamboo (*Sasa kurilensis*, *S. senanensis*).

In 1999, flux observation using eddy covariance method was launched and is ongoing. Meanwhile, biomass survey has been conducted. In addition to these ground observation, LiDAR observation of vegetation environment was carried out several times.

This forest site has been influenced by several times of disturbance including severe wind-throw damage in 2004 during these 20 years.

We report observation results and the influence of disturbance on carbon budget.

Table 1 Information of biomass survey

Area		1977	1982	1987	1992	1997	2002	2007	2012	2017
P3	50m×50m									
Pole	20m×20m×25plots									
Wing	20m×20m×40plots									

Table 2 Information of LiDAR observation

Date	Sep.,2003	Nov.,2003	Oct.,2004	Sep.,2010	Feb.,2016
LiDAR system	ALTM2050	ALTM2050	ALS50 (Leica)	ALS50 (Leica)	ALS70-HP (Leica)
Diameter of foot print (cm)	20	20	20	20	20
Pulse density (points m^{-2})	2 to 4	2 to 4	2 to 4	2 to 4	10

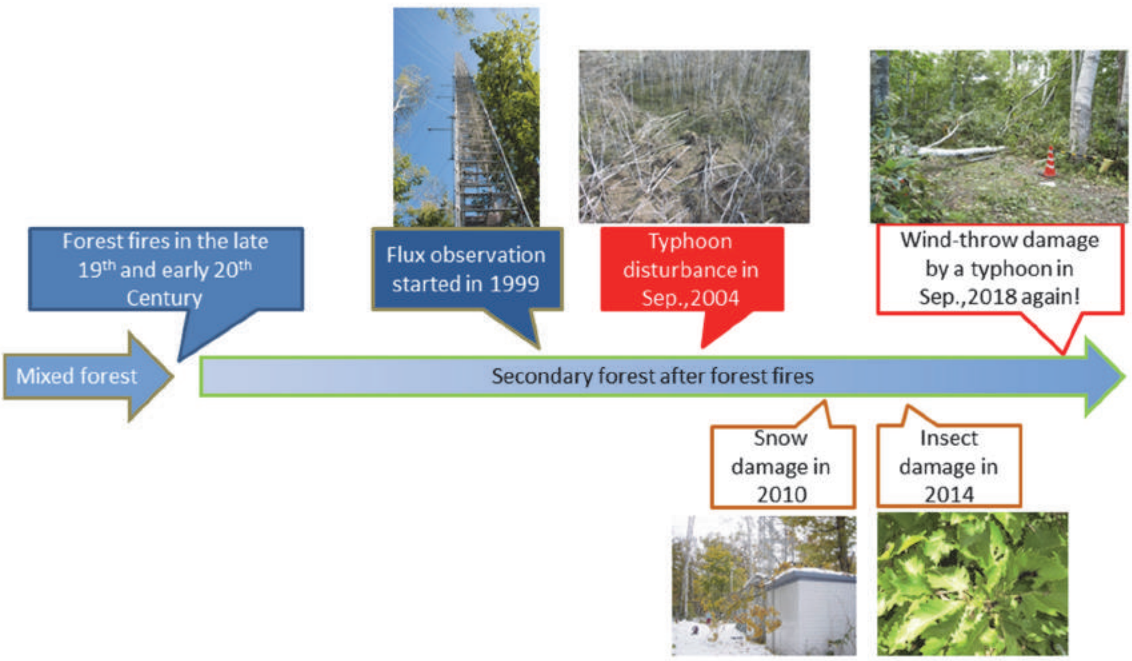

Fig.1 History of Sapporo forest meteorology research site

P2-F13

Seasonal variations of methane flux in tropical peat swamp forest in Indonesia

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The tropical peatlands in South-East Asia (SE Asia) store a vast amount of carbon and waterlogged organic matter can release potentially large volumes of CH_4 into the atmosphere, as CH_4 is produced by methanogenic archaea during the anaerobic digestion of organic matter. Satellite observations indicated significantly strong CH_4 emissions over SE Asia. On the other hand, chamber and soil incubation experiments indicated that tropical peat swamp forest in SE Asia are small sources of CH_4 (Couwenberg et al., 2010). There is a lack of data on the ecosystem-scale CH_4 flux in tropical peatlands. We observed almost 2-year variations in the ecosystem-scale CH_4 flux in an undrained peat swamp forest in Central Kalimantan, Indonesia. The aim of this study is to elucidate the seasonal variations, controlling factors, and annual budget of CH_4 flux in a tropical peat swamp forest.

The study site (2.32°S, 113.90°E) is located near Palangkaraya in Central Kalimantan, Indonesia. The site was selectively logged until the late 1990s, but still has a relatively intact forest. The average canopy height is approximately 23 m. The peat depth is 2-3 m. The annual air temperature and precipitation were 26.5°C and 2,896 mm (2016-2018). Groundwater level (GWL) varied seasonally, depending on the seasonal rainfall variations. The CH_4 flux was measured using the eddy covariance method 36.5 m above the ground between June 1, 2016 and March 31, 2018 using a sonic anemometer (CSAT3, Campbell Scientific) and an open-path CH_4 analyzer (LI-7700, Li-Cor Inc.). GWL, soil temperature and other environmental variables were measured between June 1, 2016 and May 31, 2018. The net ecosystem CH_4 exchange was calculated as the sum of eddy CH_4 flux and storage CH_4 flux. Gaps in the CH_4 flux were filled using random forest regression using GWL, friction velocity and soil temperature.

We found that the peat swamp forest switched from being a CH_4 sink during the dry season to a source of CH_4 during the wet season depending on changes in the GWL (Figure 1). The quadratic regression indicated that the CH_4 flux switched from a sink to a source when the GWL was -0.19 m. The annual CH_4 budget was -0.07 and 0.17 g C m^{-2} $year^{-1}$ from June 1, 2016 to May 31, 2017 and from June 1, 2017 to May 31, 2018, respectively. These annual CH_4 budgets were smaller compared to those reported in boreal and temperate peatlands. The annual CH_4 budget was significantly lower in 2016 than 2017 ($p < 0.05$). High CH_4 uptake and low CH_4 emission in 2016 was considered to be caused by dry environments in 2014 and 2015. The GWL decreased significantly to minimum values of -0.91 m and -1.43 m in 2014 and 2015, respectively. This implied an increased potential for the aerobic decomposition of the labile organic matter located deeper in the peat profile in the dry seasons of the two consecutive years; furthermore, the amount of labile organic matter available for anaerobic decomposition could have decreased in the 2016 wet season. Our measurement revealed that the undrained peat swamp forest was a small sink or source of CH_4 depending on the previous years' climate. Long-term measurement of CH_4 flux including wet and dry years are necessary to elucidate CH_4 dynamics in tropical peat swamp forest.

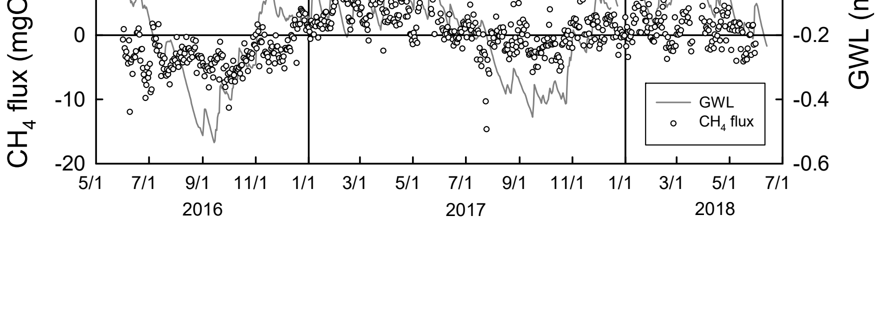

Figure 1
Variations in the daily average CH_4 flux and ground water level (GWL) between June 1, 2016 and May 31, 2018.

P2-F14

Estimation of surface soil water contents by combining water balance model with machine-learning based evapotranspiration estimates and its comparison with process-based approach

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Soil water balance models (SWBMs) are widely used to estimate soil water status under various weather conditions, which is essential information for water management and landslide susceptibility on hilly area. However, difficulties in reliable estimation of evapotranspiration (ET) which is the main component of SWBMs have been major limitation on regional application of SWBMs. Recent expansion of eddy flux measurement network in Korea provides new opportunities for understanding the spatial and temporal variation of ET and for reliable estimation of nation-wide ET. In this study, we estimated surface soil water contents at national scale by combination of SWBM and ET estimated by machine-learning based approaches and compared the results with process-based approach. First, the SWBM was tested in 10 flux measurement sites. It showed good agreements at forested sites but large errors on irrigated rice paddy sites due to lack of irrigation information. Secondly, national-scale ET estimation was conducted by using multiple machine learning (ML) algorithms, grid-based numerical weather data, and remote sensed vegetation indices. At site level, the performance of ML algorithms in daily ET estimation varied by vegetation types and site conditions, but they reproduced ET well ($r^2 = 0.75 - 0.91$). The estimated ET was used as input data into SWBM for national level soil water contents estimation. Finally, these estimated soil water contents were compared with those results from the process-based approach. Process-based estimation used Joint UK Land Environment Simulator (JULES) land surface model. The plant functional type specific parameters with high sensitivity on water flux in JULES were optimized by flux data-assimilation technique. At site level, JULES with optimized parameters reproduced both ET ($r^2 = 0.81 - 0.92$) and soil moisture well. At national level, ET from ensemble of ML algorithms and JULES estimation showed similar spatial and temporal variations, but in some areas, annual ET showed large differences (up to 20%). The surface soil water contents showed similar spatial and temporal patterns in forested area, but large differences also found on agricultural area where irrigation was poorly represented. These soil water contents estimations will be further compared with other remote sensing based soil moisture products.

P2-F15

Dissolved carbon transportation and CO_2 emissions in main rivers of the Tibetan Plateau

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Rivers are critical links for the carbon cycle in aquatic, terrestrial, and atmospheric environments. In this work, we provided an overview of the dissolved carbon (i.e. dissolved inorganic carbon [DIC] and dissolved organic carbon [DOC]) and CO_2 exports in rivers on the Tibetan Plateau. Compared with the world average, concentrations of DIC (30.7 mg L^{-1}) are fairly elevated in rivers of the plateau due to the extensive topographic relief and intensive erosion. While concentrations of DOC (1.39 mg L^{-1}) are low due to the low temperature and unproductive land vegetation on the Tibetan Plateau. Nevertheless, radiocarbon of the DOC in most rivers of the plateau are more depleted/older (872±626 years before present, ybp) than those in many other rivers in the world. Much of the DOC present was from terrestrial (e.g., humic) sources, indicating that the old carbon stored in the permafrost of the plateau is being exported to river systems during the period of high flow. Furthermore, there was a significant relationship between concentrations of dissolved carbon and carbon dioxide (CO_2) in rivers of the Tibetan Plateau. Despite low partial pressures of CO_2 (864 μatm), the emission fluxes of CO_2 (3,452 mg-C m^2 d^{-1}) during the summer half of the year in rivers of the plateau are comparable with most other rivers in the world. Therefore, with global warming, an increasing export of carbon substances (including CO_2 emissions) from rivers of the Tibetan Plateau can be expected in the future, which will potentially add feedback to the regional production of greenhouse gasses.

Keywords: Dissolved carbon; Carbon isotope compositions; Greenhouse gases; Rivers; Tibetan Plateau; Climate change

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P2-F16

Atmospheric deposition of nitrogen, phosphorous, and acid in Chinese ecosystems: dynamics, patterns, and the influencing factors

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The atmospheric deposition of nitrogen, phosphorus, and acid is increasing due to human activities. This may not only bring negative effects on ecosystem, such as biodiversity damage, soil acidification, reducing soil buffer capacity, but also bring positive effects on ecosystems, such as providing nutrient element, increasing crop yields, promoting forest growing, and so on. Therefore, it will be helpful for evaluating the impact of atmospheric nitrogen, phosphorus, and acid deposition to ecosystem processes and functioning to explore their dynamics, patterns, and the influencing factors.

Based on Chinese Ecosystem Research Network (CERN) and other stations, we established the Observation Network of Atmospheric Chemistry Deposition in typical terrestrial ecosystems (China_WD) which consists of more than 50 ecosystems covering forest, grassland, cropland, desert, lake, wetland, and city. The network observes atmospheric nitrogen, phosphorus, and acid deposition simultaneously. Based on the observation data, we quantitatively analyzed the spatio-temporal variability, influencing factors and driving forces of atmospheric nitrogen deposition in China, the spatio-temporal pattern and its influencing factors of precipitation acid deposition, the atmospheric phosphorus deposition, N:P and its ecological implications in typical ecosystems in China.

The results showed that the annual average flux of atmospheric wet deposition (ammonium nitrogen and nitrate nitrogen) in China was about 12.4-13.8 kg ha^{-1} a^{-1}, significantly higher than that of America and European region; high nitrogen deposition region located in Central China and Southern China, while low nitrogen deposition region located in Northern China, Western China, Neimenggu and Qinhai-Tibetan. The average ratio of NH_4^+/NO_3^- was 1.22 in wet deposition. The main factors that control the spatial pattern of wet nitrogen deposition were nitrogen fertilizer utilization, energy consumption, and precipitation. The average pH value in precipitation was 6.2 in Chinese natural ecosystems and croplands, and the acid deposition exhibited an aggravation trend from north to south, with the most serious region in southwest region; energy consumption and precipitation affect acid deposition significantly. The annual average value of phosphorus deposition in precipitation was about 0.21 kg P ha^{-1} a^{-1} in Chin, the ratio of N:P was 77:1 in atmospheric wet deposition, and the imbalanced input of nitrogen and phosphorus might have impact on ecosystem productivity and biodiversity in Chinese terrestrial ecosystems.

P2-F17

18 years to compensate all CO_2 emission after a clearcut harvesting in a cool-temperate forest

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A mixed forest in northern Japan, which had been a weak carbon sink (net ecosystem CO_2 exchange = –0.44 MgC ha^{-1} yr^{-1}), was disturbed by clear-cutting and was replaced with a hybrid larch (*Larix gmelinii* × *L. kaempferi*) plantation. To evaluate the impact of the disturbance on the ecosystem's carbon budget, we conducted 19 yr (2001–2019) of eddy covariance measurements of CO_2 fluxes. The ecosystem turned to be a large CO_2 source just after the harvesting in 2003, and the cumulative net CO_2 emission reached up to 15.4 MgC ha^{-1} at 7 years after the harvesting, then the ecosystem turned to be a CO_2 retrieve mode (CO_2 sink in the annual budget). 81% of the net CO_2 emission was retrieved by the end of the year 2018, and this ecosystem will recover all CO_2 emission 18 years after the harvesting in 2020, if off-site carbon storage in forest products is not considered. This implies one anthropogenic disturbance cause large invisible and long-lasting effect on the forest ecosystem carbon balance.

P2-F18

The influence of precipitation pulses on surface energy balance and evapotranspiration over an arid shrubland

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The episodic precipitation pulses in dryland environments has significant consequences on the patterns of the surface radiation balance, energy partitioning and evapotranspiration. Continuous measurements of the surface radiation, energy fluxes and evapotranspiration using an eddy covariance and automatic weather station were made for two years at an arid shrubland, in the middle part of the Hexi Corridor regions of northwestern China. The average midday time net radiation for clear-sky days after rainfall events was increased by roughly of 10% with the addition of soil moisture, caused mainly by decreases in albedo and in surface thermal radiation loss when compared to that prior to rainfall events. Even small rainfall events can have a very large impact on the surface energy balance because the energy and moisture budgets at the shrubland surface are principally linked by evaporation, which is an expenditure of both energy and water mass. The average latent heat flux is increased by about a factor of 2.5 with the addition of moisture at top soil layers replenished by rainfall. There was a corresponding decrease in sensible heat flux after rainfall by approximately 10%, compared with that before rainfall. The wet soil heat flux was lower about 20% than the dry soil heat flux. Consequently, a wet soil decreased surface temperature by more than 6 °C and increased the available energy (i.e., difference between net radiation and soil heat flux) by more than 20%. Evapotranspiration peaked in July due to more soil water content caused by the relative frequent rainfall events. The increased evapotranspiration just after rainfall events was mainly contributed to increase in evaporation from soil and shrub canopy. However, the difference in transpiration of shrub canopy was very small between after and before rainfall events. This is because these shrub species primarily are dependent on groundwater. So, the coupling between precipitation and these shrubland might be very weak, although water is the main limiting factor for most desert vegetation. These results might provide a significant implication for ecotone conservation (or, reforestation) and water resources management in the arid areas.

P2-F19

Long term variation of CO_2 flux at cool temperate red pine forest in Japan

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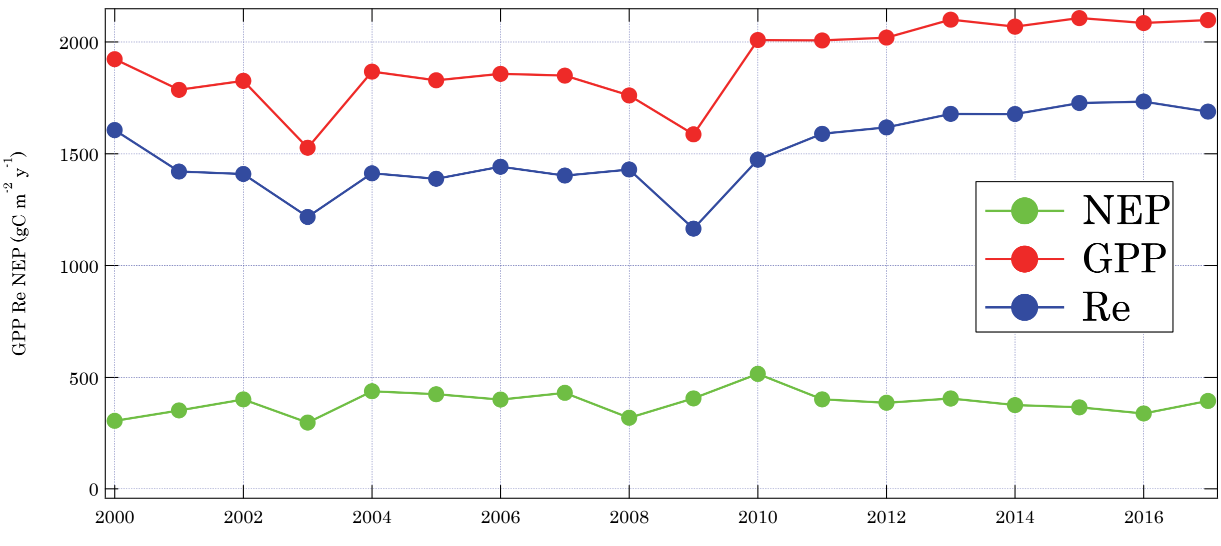
Carbon dioxide (CO_2) flux have been measured above the forest at the Fujiyoshida site on the northern slope of Mount Fuji in Japan from 2000 using an eddy covariance method. The forest mainly consists of Japanese redpine (Pinus densiflora) and Japanese holly (Ilex pedunculosa). Forest total biomass was 141 tC ha^{-1} and stand age was about 100 years(Ohtsuka et al. 2013). Closed path eddy CO_2 flux system and instruments for measuring meteorological conditions were equipped at a scaffold tower 32 m in height.

The 19-year (from 2000 to 2018) average of monthly mean net ecosystem production (NEP) ranged from -0.1 gC m^{-2} day^{-1} in January to 2.7 gC m^{-2} day^{-1} in May. The maximum net uptake was observed in May, although gross primary production (GPP) was highest in July. The 18-year averages of annual NEP, GPP, and ecosystem respiration (RE)were 387, 1,906, and 1,505 gC m^{-2} year^{-1}, respectively. The annual NEP was lowest in 2003(298 gC m^{-2} year^{-1}) and highest in 2010(516 gC m^{-2} year^{-1}) over the 19 years. And yearly NEP had positive relation with air temperature.



P2-F20

Long-term variations in the carbon budget and the atmospheric CO_2 concentration detected from 26-year observation in a cool-temperate deciduous forest at Takayama

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Climate change and its impacts on human and natural systems have been our critical concern. Various changes in terrestrial biospheric activities due to climate change have been discussed in many recent studies. Given that East Asia is strongly influenced by the Asian Monsoon, climatic changes not only in the temperature but also in the amount of precipitation and the length of the rainy season associated with the monsoon would have a major impact on the terrestrial carbon budget. However, there are still large uncertainties in the estimation of responses of the terrestrial biosphere to climate change. We can reduce these uncertainties by analyzing long-term measurements related to the terrestrial carbon budget.

We have made long-term systematic measurements of the CO_2 flux between the atmosphere and the forest ecosystem, the atmospheric CO_2 concentration, and meteorological parameters in a cool-temperate deciduous forest at Takayama (TKY; 36°08'N, 137°25'E, 1420 m a.s.l.), Japan since 1993. TKY is the longest monitoring site in the AsiaFlux network. Using these data, we have examined their inter-annual variations, long-term trends and environmental factors governing these variations. The main results obtained from the analyses are as follows:
(1) The annual net ecosystem production (NEP) and the annual gross primary production (GPP) vary significantly from year by year, while inter-annual variation in the annual ecosystem respiration (ER) is relatively small. The inter-annual variation in the annual NEP depends strongly on the annual GPP.
(2) Inter-annual variation of the annual NEP shows a statistically significant positive correlation with those of the monthly NEP in June and July. Higher insolation during the summertime tends to produce higher amount of the annual NEP.
(3) In the warm-spring years, beginning of the daily positive NEP and the spring downward zero crossing of atmospheric CO_2 concentration tend to occur early.
(4) Significant long-term trends in the increased annual NEP, GPP and ER and the enhanced seasonal amplitude of atmospheric CO_2 above the canopy during the daytime are found.

P2-F21

Simulation of methane dynamics in a mid-latitude eutrophic lake with constraints using incubation data

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Lake is an important source of methane (CH_4) contributing to approximately 10 % of total natural source. Developing a lake CH_4 emission model is one of the tasks for improving the accuracy of climate simulation. LAKE2.0 is a process-based lake simulation model which includes CH_4 dynamics module, and have been evaluated against CH_4 dynamics in boreal lakes. Further validations are called for to apply the model to lakes with different trophic level in different climate. We applied and validated this lake model to a mid-latitude eutrophic lake, Lake Suwa, in Japan where data of eddy covariance CH_4 flux, dissolved CH_4 concentration, and production and oxidation rate obtained by incubation experiments are available.

LAKE2.0 is a horizontally-integrated one-dimensional lake model which is composed of physical and process-based biogeochemical modules. The lake mixing and turbulent diffusion of dissolved gasses are calculated based on the k-e turbulence closure scheme. CH_4 production is modeled to increase with temperature with Q10 relationship and to decrease with sediment depth, with a parameter to determine the maximum CH_4 production rate at the sediment surface. CH_4 oxidation is modeled to increase with dissolved CH_4 and oxygen concentrations, with a parameter to determine the maximum CH_4 oxidation rate without CH_4 and oxygen limitation. We improved the accuracy of oxidation module by adding Q10 temperature dependence to the default module. Oxygen dynamics are also incorporated in the model.

Lake Suwa is a shallow eutrophic lake located in central Japan. In this lake, we have installed an observation mast at a pier on the southeast shore where meteorological conditions were monitored. These data were used to drive the model simulation. Lake water and sediment were periodically sampled, and incubated under different temperature conditions to determine CH_4 oxidation and production rates, respectively, and their temperature dependence.

Simulation of water temperature and sensible and latent heat fluxes into the atmosphere showed a reasonable agreement with observations, suggesting the physical module of the model is relatively sound. Whereas, simulated dissolved oxygen concentration was overestimated during winter, and consumption of oxygen in the bottom water layer in summer was not reproduced well. We adjusted sediment oxygen demand in the oxygen dynamics module and this improved the reproducibility of summer dissolved oxygen concentration. The overestimation in winter dissolved oxygen concentration remained, however the oxidation rate has less dependency on dissolved oxygen concentration in the oxygen level observed.

The parameters in the CH_4 production and oxidation modules were determined using production and oxidation rate data obtained from incubation experiments. By optimizing the parameters, the production module can explain 49 % of variation in observations. Similarly, the parameters for oxidation were determined, and the reproducibility of oxidation module was improved by taking the temperature dependence into account, explaining 40 % of variation in observations.

Simulated dissolved CH_4 concentration showed a reasonable agreement with the observations owing to the parameter optimization and by considering the temperature dependence in oxidation module. Resulting CH_4 emission simulated showed a reasonable seasonal variation with 25 % overestimation compared to the observations. Simulated diffusive emission contributed to, on average, 7 % of the total emission. This contribution was underestimated compared to partitioned eddy covariance diffusive CH_4 flux, suggesting a need to improve the module of emission pathways.

In conclusions, the structure of LAKE2.0 model is sound, and the use of appropriately determined parameters results in a reasonable simulation of CH_4 dynamics. Further efforts should be made to improve the biogeochemical module and to predict the variation of parameters among different lakes.

P2-F22

Reanalysis of 20 years data at TKY

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TKY site is located at 36.146°N, 137.423°E (JGD2011), 1420 m above sea level in deciduous forest in mountainous area. The flux measurement with gradient method and other micro meteorological observation started in 1993 at 25 m tower (flux tower). Since 1998 eddy-covariance measurement of fluxes have been started. Looking back these 20 years, however, there are many gaps of measurement and data correction was not always completed. We are now trying data correction and gap filling of the data and checking a trend during 20 years. At first gap filling of temperature and VPD at 25 m above the ground was performed using the data at other levels or those at River basin research center, Gifu University at 400 m south of TKY site. The data of long-wave radiation before 2007 is much shifted and data correction was tried using temperature data at TKY.

Although these gap fillings and data correction are very important, long-term observation give more confident tendency of the fluxes and variables due to increasing sampling numbers, even though there are many gaps. For example, Saigusa et al. (2002) tentatively employed exponential relationship between night-time CO_2 flux and temperature, however, 20 years data showed that CO_2 flux at nighttime decline at higher temperature than 17°C (Fig. 1). This is because high temperature at TKY is associated with large VPD. A remarkable trend is increase of downward short-wave radiation due to improvement of air quality around Japan (Fig. 2).

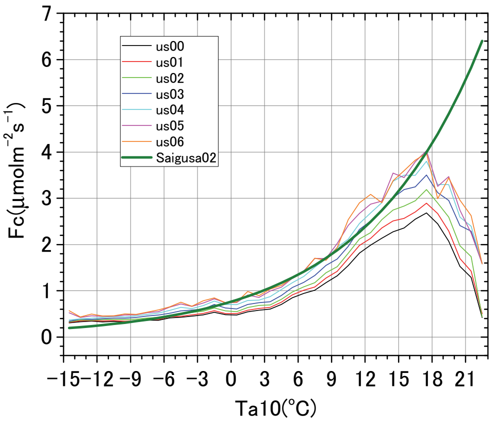

Fig.1 Relationship between temperature at 10m and CO_2 flux at night. us** means ustar-correction value (01: 0.01m/s). Saigusa02 is exponential form in Saigusa et al. (2002).

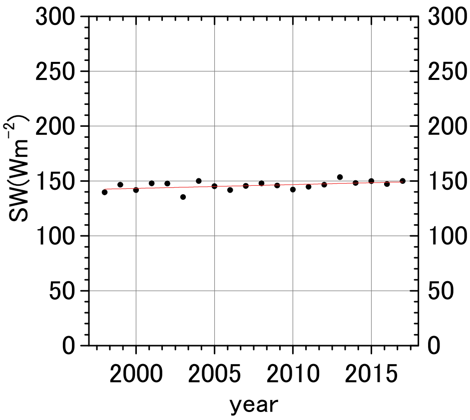

Fig.2 Trend of downward short wave radiation. Increasing trend is significant with significant level of 0.05.

Reference

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P2-F23

Discrepancy in phonological indicators derived with CO_2 flux, MODIS image and ground monitor at a temperate mixed forest and an alpine shrub ecosystem

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To accurately assess the change of phenology is one of the key issues in context of global change, however, different patterns were presented resulted from diverse methods and data sources using to extract vegetation phenology. In this study, an alpine shrubland meadow in Haibei (HBS) of Qinghai-Tibetan plateau and a broad-leaved Korean pine forest in Changbai Mountain (CBM) of Northeastern China were selected to investigate the convergence of phonological indicators derived with ecosystem carbon flux, satellite images and ground observation. Based on the long-term GPP from eddy flux measurements and the Normalized Difference Vegetation Index (NDVI), phenological indicators including the start of growing season (SOS), the end of growing season (EOS), and the growing season length (GSL) since 2003 were derived via multiple frequently-used methods. Compared with ground phenology observations of dominant plant species, both GPP- and NDVI-derived SOS and EOS exhibited a similar interannual trend. GPP-derived SOS was quite close to NDVI-derived SOS, but GPP-derived EOS differed significantly from NDVI-derived EOS, and thus leading to a significant difference between GPP- and NDVI-derived GSL. Relative to SOS, EOS presented larger differences between the extraction methods, indicating large uncertainties to accurately define EOS. In general, among the methods used, the threshold methods produced more satisfactory assessment on phenology change. The results also indicates that how to harmonize with the flux measurements, remote sensing and ground monitoring are a big challenge that needs further consideration in phenology study, especially the accurate extraction of EOS.

Key words: phenology, carbon flux, NDVI, GPP, photosynthesis, alpine shrub, temperate forest

P2-F24

Assessing the net carbon flux to the atmosphere from land-use change in tropical peatland- the new emissions that the atmosphere will see

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Since the 1980's, extensive areas of Indonesian peatlands have experienced rapid land-use change that eventually led small-holders and industrial agriculture establishment. One of the most important environmental consequences of land-use change, yet poorly understood, is the associated change in greenhouse gas exchange with the atmosphere. From a climate forcing viewpoint, assessing the anthropogenic impact of land-use change on greenhouse gas exchange should account for the net change (positive or negative) in greenhouse gas exchange with the atmosphere resulting from land-use change, that is the new emissions that the atmosphere will see. This has remained mostly unaddressed in the scientific literature as well as in debates on the environmental acceptability of agriculture development on tropical peatlands. An understanding of greenhouse gas exchange over a natural landscape is therefore needed to provide a baseline to quantify the net impact of land-use change on greenhouse gas exchange. This information is relevant to scientists and policymakers to better understand how land-use changes affect the greenhouse gas exchange.

In this context, we set out to measure the net ecosystem-atmospheric exchange of carbon dioxide using the eddy covariance technique over three different land-uses in peatlands of the Kampar Peninsula in the east coast of Sumatra, Indonesia: a natural forest, a plantation forestry (*Acaci*a *crassicarpa*), and a mixed land-use.

Initial observations indicated that on the annual basis, all three ecosystems including the natural forest functioned as carbon dioxide source to the atmosphere. Notably, the *Acaci*a plantation functioned as carbon dioxide neutral at canopy closure which occurred 6-7 months after planting. Therefore, we cannot yet assess the net effect of planation forestry on carbon flux. To fully capture the carbon dioxide exchange dynamics over a five year plantation cycle, we plan to continue the measurement over a full five year plantation cycle. This presentation discusses preliminary results and their potential implications for land-use policy.

P2-F25

The greenhouse gas and energy balance of a commercial oil palm plantation in tropical lowland Jambi province (Sumatra, Indonesia)

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In the past decades Indonesia has experienced substantial land-use changes from forests to oil palm (*Elaeis guineensis* Jacq.) plantations due to the world's high demand for cheap vegetable oil in pharmaceutical, cosmetics and food industry as well as for biofuel. Oil palm expansion affects ecosystem properties and functions such as biodiversity, microclimate, carbon pools and greenhouse gas (GHG) balance. However, there is still no information on the annual CO_2 budgets of oil palm plantations at the ecosystem scale. Further, the overall high rate of nitrogen-based fertilization in the oil palm plantation, and related emission of nitrous oxide (N_2O) raises concern over potential long-term impact of oil palm agricultural practices on climate. With respect to climate change, changes in precipitation pattern and increase in the magnitude and frequency of extreme events such as El Niño Southern Oscillation (ENSO) may severely stress oil palm plantations in the near future.

In this study, we therefore aim to quantify the full GHG and surface energy exchange, as well as micrometeorology in a large scale mature commercial oil palm plantation in the tropical lowlands of Jambi province (Sumatra, Indonesia) to gain an understanding of oil palm GHG budget, global warming potential, surface energy exchange as well as oil palm response to meteorological extremes such as ENSO. We established our ongoing measurements in mid-2014.

Our results show that the oil palm plantation has a strongly negative net ecosystem exchange (NEE) that represents a large on-site sink of CO_2 (-2750 g CO_2-eq. m^{-2}). However, when yield is considered, the plantation turns into a net source of CO_2 (550 g CO_2-eq. m^{-2}). N_2O plays an important role in the GHG balance of the plantation due to high fertilizer application (170 g CO_2-eq. m^{-2}) while the role of CH_4 is negligible (-0.13 g CO_2-eq. m^{-2}) due to the high mineral content of the soil. Considering the contribution of all GHG fluxes, the oil palm plantation has a substantial global warming potential of 720 g CO_2-eq. m^{-2}.

The oil palm plantation has high water consumption, with evapotranspiration of 1368 ± 545 mm yr^{-1} and the Bowen ratio (ratio of sensible (H) to latent heat flux (LE)) of 0.16 ± 0.12 shows that LE is by far the dominant turbulent heat flux. The episodically reoccurring ENSO event, however, distinctly alters the GHG and surface energy balance of the oil palm plantation. We found that during the 2015-2016 ENSO event, drought and smoke haze conditions from emerging forest fires, with related increase in atmospheric vapor pressure deficit and air temperature, and changes in light conditions are major disturbing factors for the oil palm plantation. The strong haze amplified the negative effects of the drought and haze conditions resulted in a complete pause of oil palm net carbon accumulation for about 1.5 months and contributed to a decline in oil palm yield by 35%. It is very likely that without the haze, the negative impact on CO_2 fluxes, net carbon accumulation and yield would have been less pronounced.

P2-F26

The differences of net ecosystem production changes between Pinus koraiensis plantation and mixed forest over four years after drought event

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As climate change progresses, regional variability in extreme weather events such as drought will increase and is expected to have a significant impact on the carbon cycle of forest ecosystems. Therefore, it is important to understand the change of carbon cycle of forest ecosystem due to drought and the recovery after drought. In this study, we analyzed the changes of net ecosystem production(NEP) using the eddy covariance system and the recovery of NEP after drought using the recovery index(RC NEP) at evergreen needle-leaf forest(ENF) and at nearby mixed forests(MF) where Quercus species are dominant in Mt. Taehwa, Central region of Korea during four years from 2015 to 2018. As a result of standardized precipitation index(SPI) analysis, drought occurred in 2014 continued until July of 2017 when 561 mm of heavy rain fell. And the soil water content at ENF decreased more than 9% than that at MF due to the worst drought in May and June, 2017, which lasted from last autumn. The annual NEP in 2017 except for the non-growing season of winter decreased more at ENF than MF. In particular, NEP in May and June of 2017 at ENF decreased by 44.1±8.0 g C m-2 on average compared with May and June of the other three years, and it was more than twice 17.6±59.2 g C m-2 at MF. The reason for the difference between ENF and MF was that soil moisture content at ENF largely decreased lower than the plant's wilting point, and photosynthesis rate decreased with stomata closure. Furthermore, it turned out to be affected by evapotranspiration and canopy interception during non-growing season as well as low precipitation. The annual NEP in 2018 excluding winter increased by 85.1±42.0 g C m-2 and 239.0±64.9 g C m-2 on average compared with the other three years at ENF and MF, respectively. Thus, RC NEP at ENF was 1.16±0.10, which was lower than 1.34±0.13 at MF, and it seemed to be attributed by drought legacy effect at ENF. The results of this study show that carbon cycle at ENF can be more greatly affected by drought than MF due to leaf presence during winter and spring drought, and the recovery of NEP at ENF may be delayed after drought because of legacy effect.

P2-F27

Carbon dioxide exchanges over the secondary dry dipterocarp forest in Thailand as affected by the 2015/2016 strong El Nino

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Researches in the past indicate that about 25% of the terrestrial carbon is stored in tropical forests and climate variability such as warming and drying during El Niño have been suggested to reduce carbon uptake. In this study, we investigated the effects of a recent El Niño event on trace gases and energy exchanges over a secondary dry dipterocarp forest in Ratchaburi, western Thailand. The El Niño 2015/2016 is one of the top three strongest El Niño events in the historical record since 1950. This strong El Niño started at the end of 2014, peaked in late 2015, and ended in May 2016. It has triggered a widespread drought in Southern Asia. At our study site, the effects of this El Niño was observed 3-4 months after the onset of this strong El Niño and especially obvious during dry season. The rainfall amount was 40.7% lower than the average. The dry season with low soil moisture and high temperature lasted about 6-7 months during the El Niño compared to 3-4 months during the usual dry seasons. In this forest, usually net carbon loss is occurred during the dry season. We found that carbon loss during dry season was increased about three times, from 40-60 gC m^{-2} during non-El Niño to 152 gC m^{-2} during the strong El Niño. The dry season GPP and RE were also reduced significantly by El Niño. However, the annual NEP during the 3 years period have increased continuously from 527.26, to 721.02 and 1,039.97 gC m^{-2} $year^{-1}$ in 2015, 2016 and 2017, respectively. The annual NEP in 2015/2016 continued to increase despite hitting by strong El Nino can be explained by the carbon uptake in wet season that so active and could compensate the extra carbon loss in dry season. The annual GPP and RE in 2015/2016 were approximately 9.64-22.23 and 17.70-21.66 %, lower than that of the usual years, respectively. Thus, RE seems to be more sensitive than the GPP. In addition, the ET in dry season 2015/2016 was 296.7 mm, 37.88 % lower than the averaged ET in usual dry seasons (477.62 mm). The annual ET in 2015/2016 (1,014.33 mm) was 18.70% below than averaged ET during 2014/2015 and 2016/2017 (1,247.63 mm).

P2-F28

Inter-annual variations in carbon sequestration of Inner Mongolia semi-arid grasslands

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Semi-arid ecosystems play an important role in regulating the dynamics of the global terrestrial carbon cycle and are a major cause of inter-annual variability and uncertainty in global CO_2 uptake. However, it is still not well understood on the control mechanism on inter-annual variations (IAV) in carbon fluxes and sequestration. Here, long-term carbon fluxes in semiarid grassland sites of Inner Mongolia were presented and we found the typical semiarid grasslands act as a net carbon sink with an average annual NEP of -47.56 ± 38.09 g C m^{-2} $year^{-1}$ based on decade years eddy covariance observation. Precipitation and its seasonality is the most important driver of inter-annual variations in ecosystem photosynthesis and respiration, therefore carbon sequestration. Additionally, leaf area index, soil water content and air temperature are also play a role on the inter- and intra-annual fluctuations of carbon exchange.

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Key words: Net ecosystem exchange (NEE), inter-annual variation, semiarid grassland

P2-F29

Ecosystem Carbon and Nitrogen Dynamics of Tropical Peatland (ECaNDoTP): Cross-site comparison of trace gas exchange between managed tropical peatlands in mainland and insular Malaysia

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Oil palm is the largest agricultural crop in the tropics, accounting for 13 % of all tropical land cover. Due to its large areal extent, oil palm cultivation may have important implications not only for terrestrial stores of C and N, but may also impact regional and global exchanges of material and energy, including fluxes of trace gases and water vapor. In particular, recent expansion of oil palm into tropical peatlands has raised concerns over enhanced soil C emissions from degradation of peat, and elevated N-gas fluxes linked to N fertilizer application. The principal goal of this project is to quantify greenhouse gas fluxes at the forest and oil palm sites. The wider goal of this activity is to conduct a cross-site comparison with forest and oil palm sites in Sarawak (insular Malaysia) and Pahang (mainland Malaysia), in order to identify both generic (i.e. cross-site) and site-specific trends in GHG fluxes and environmental variables. Collectively, these data will enable us to develop a more robust picture of the climate impacts of oil palm production across different parts of Malaysia and will enable us to develop generic and site-specific strategies for mitigating GHG emissions. The ultimate challenge is to ensure sustainable plantations integrating ecosystems, society, environment and the economics.

P2-S1

Soil CO_2 fluxes in a tropical lowland ever-green secondary forest in Pahang, Peninsular Malaysia

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Soil respiration is a key component of the terrestrial ecosystem carbon cycle. It is a sum of root respiration and the heterotrophic decomposition of soil organic matter. Climatic conditions, mainly rainfall and soil temperature are known to influence soil respiration. In this paper, we aim to determine the differences between microbial respiration and root respiration using the trenching method in a lowland secondary forest in Peninsular Malaysia. We randomly placed 8 trenched and untrenched plots sized 1m^2 in a 0.8 ha of Jengka Forest Reserve, Pahang (3º 35' N, 102º 34' E) in early June 2017 and started our measurements in October 2017. Data which was collected include soil respiration using automated soil CO_2 flux system (Li-8100A) every 4 months (8 replicates/treatment), soil water filled pore space, soil temperature, relative humidity, soil bulk density and other environmental variables. Data collected from October 2017 to February 2019 displayed the values for soil respiration were 15-21% relatively higher (271.77-784.08 C mg CO_2 m^{-2} h^{-1}) compared to microbial respiration except for October 2018 due to instrumental error. The root respiration were markedly lower in all plots. Soil water filled pore space (soil moisture) were relatively higher in trenched plots (0.3- 4.3%) compared to untrenched plots, possibly indicating the utilization of water in untrenched plots for both microbial and root respiration processes. There were no distinctive variations on soil temperature in both plots. This measurements are on-going and our preliminary data suggests that soil moisture plays a pivotal role in soil flux measurements. Soil fluxes recorded are comparable to Pasoh Forest Reserve (Adachi et al., 2006). Data on fine root biomass and decomposition are on-going.

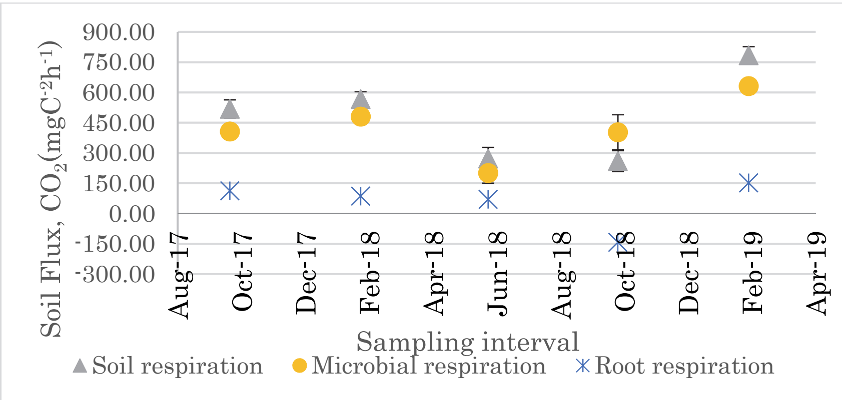

Figure 1: Soil carbon dioxide fluxes from tropical secondary forest

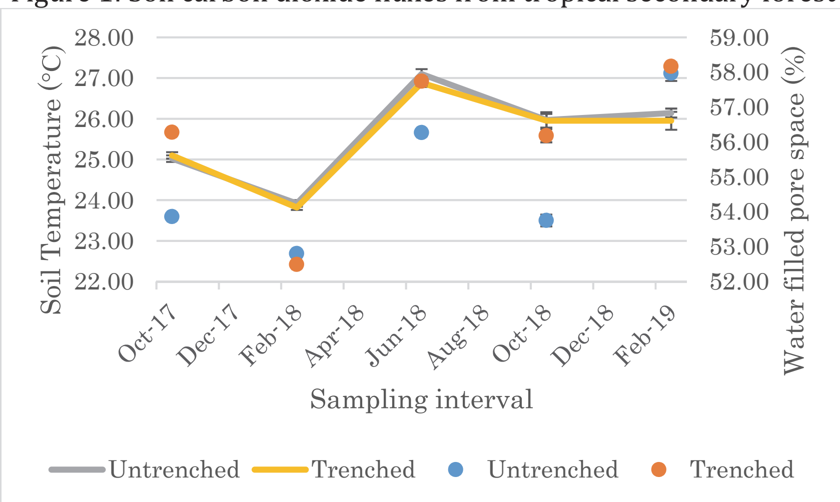

Figure 1: Soil temperature and water filled pore space from tropical secondary forest

P2-S2

Analysis of soil characteristics of the agrometeorological observatories in Korea for the production of high quality soil moisture data

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The Korea Meteorological Administration (KMA) conducts soil moisture observations at 11 national sites as one of the elements of agrometeorological measurement, but the utilization of those data is insufficient. As the problem of climate change deepens, it is becoming more important to produce high quality soil moisture data and to improve its usability in the agricultural sector. Establishment of correct soil moisture observation method, periodic sensor calibration and understanding of soil characteristics for measurement sites are the basis for this. This study mainly deals with the analysis of soil characteristics at observation points in this series of processes. Soils were sampled at four different depths (10 cm, 20 cm, 30 cm and 50 cm from the surface) to understand their physical characteristics and four analyses were performed: volumetric water content, bulk density, soil texture and soil water holding capacity. The volumetric water content of the samples was obtained by subtracting the weight of the dried sample from the total one of the sample and dividing by the volume of the core. These values were compared with the observations of existing sensors at the time of sampling. Although some points have less deviation or the similar tendency of change according to depth, the cases where they did not agree were also significant. This result shows that precise calibration of the sensor values at each point and depth is required. Bulk density is a value obtained by dividing the weight of the dried soil sample by the volume of the core and generally tends to increase with the depth of the soil. In this study, however, the tendency of change in the upper and lower parts of the soil was often different, and it was concluded that the soil properties of the two parts did not match in the process of covering the original soil with the external one on setting those sites up. The contents of sand, silt and clay were investigated by classifying the particle size of collected soil samples, resulting in the characteristics of sandy loam or loamy sand for most of the sites. As the portion of sand of these soil types is relatively higher than that of the soil types, such as loam or silty loam, on the adjacent actual farmland, it is necessary to reflect the difference in the soil moisture behavior between these two soil types. Lastly, the sampled soil was saturated with water, and the residual moisture was measured after applying various pressures (0.3 bar, 1 bar and 15 bar) to obtain the soil moisture characteristic curve of each soil. The pressures of 0.3 bar and 15 bar are related to the field capacity and the permanent wilting point of the soil, respectively. Field capacity of the soil samples was mainly distributed in the range of 20-30% with the large variation. Permanent wilting point was also the lowest at 2.6%, and the highest at 41%. The effective water content between field capacity and permanent wilting point was about 10%. This information will be used as a basic data to make a correction formula for each site by comparing the measured values of the sensors installed in the field with the ones of the reference sensors calibrated in the laboratory in the future.

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P2-S3

Development of reference soil moisture measurement system for calibration of soil moisture sensor

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Soil moisture accounts for a very small proportion of the water present on earth, but it is an important component controlling water, energy, and carbon exchange between land surface and atmosphere. It has significant effects on various fields such as agricultural productivity, flood and drought severity, water resources security, so understanding the patterns of temporal and spatial variation of soil moisture is important. The World Meteorological Organization (WMO) has designated soil moisture as one of the essential climatic variables in 2010 and actively encourages to apply it to research in various fields. Therefore, the importance of accurate soil moisture measurement is increasing. Although the large improvement of soil moisture sensors, still sensitivity and reliability of soil moisture sensors are one of main obstacles in soil moisture monitoring. This study introduces a reference soil moisture measurement system for detecting measurement errors of a soil moisture sensor and calculating its calibration coefficients. This system consists of load cell weight sensors, and soil moisture sensors to be calibrated. The system can measure changes of weight by adding or removing of water in the soil and calculate gravimetric soil water contents in real time, which enables quick and accurate comparison with values from various soil moisture sensors. For calibration, constant amount of water is added to the soil periodically, and changes of gravimetric soil water contents are compared with values from soil moisture sensor. We selected EnviroSCAN® soil moisture sensor (Sentek Sensor Technologies, Stepney, SA, Australia) which is possible to be separated the sensor unit with the access tube. This enables users to install only the access tube at the measuring point at first and to add the sensor unit at necessary periods later. After calibration, this sensor will be used as a reference sensor for other soil moisture sensors.

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P2-S4

Soil respiration rates of Japanese cypress (*Chamaecyparis obtusa* Endlicher) stands regenerated from a pine wilt disease forest

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This study was performed to measure the soil respiration (soil CO_2 fluxes) rates of Japanese cypress (*Chamaecyparis obtusa* Endlicher) stands planted in pine wilt disease-disturbed forests. Twelve plots with three treatments [four plots of undisturbed pine stands (NP), four plots of Japanese cypress planted under slightly disturbed pine stands (DP), and four plots of Japanese cypress planted following clearcutting of severely disturbed pine stands (CP)] were established in pine wilt disease-disturbed forests in Southern Korea. *In situ* soil CO_2 fluxes rates were measured by Licor-8100A from January to December 2018. Mean soil CO_2 fluxes during the study period were significantly higher ($P < 0.05$) in the NP (2.04 µmol m^{-2} s^{-1}) than in the DP (1.09 µmol m^{-2} s^{-1}) and CP (1.33 µmol m^{-2} s^{-1}) plots. Mean soil temperature and soil water content were not significantly different among the three treatments ($P > 0.05$), whereas mean soil pH was significantly lower in the NP (pH 4.50) than in the DP (pH 4.86) and CP (pH 4.72) plots. There were exponential function relationships between soil CO_2 fluxes and soil temperature in the three treatments. The coefficient of determination (R^2) was higher in the CP (0.79) and NP (0.78) plots than in the DP (0.60) plots. Q_{10} values were also higher in the CP (3.7) followed by NP (2.83) and the DP (1.96) treatments. These results indicate that soil CO_2 efflux rates following clearcutting regeneration may be more sensitive to changes in soil temperature when compared with other treatments.

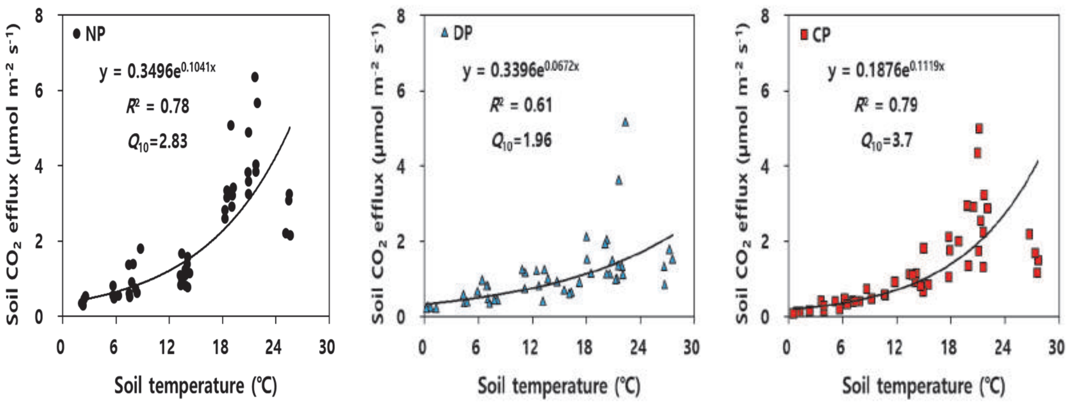

Figure 1. An exponential regression of soil CO2 efflux against the soil temperature in of Japanese cypress stands regenerated from a pine wilt disease forest (NP: undisturbed pine stands; DP: Japanese cypress planted under slightly disturbed pine stands; CP: Japanese cypress planted following clearcutting of severely disturbed pine stands).

Seasonal variations of isoprene and monoterpenes concentrations in six forests between cool temperate and subtropical zone in Japan

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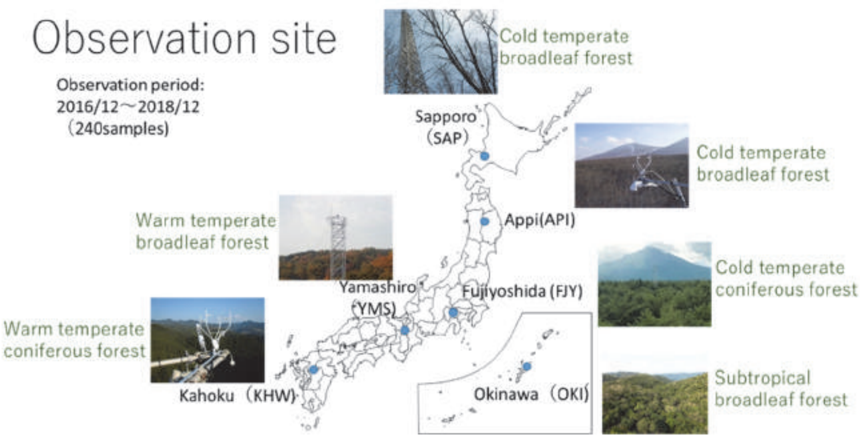
With respect to radiative forcing, forests have the following two primary effects: carbon fixation and emission of biogenic volatile organic compounds (BVOCs). BVOC emissions are much higher than anthropogenic volatile organic compound emissions. BVOCs are precursors of secondary organic aerosols (SOAs), which exhibit a negative radiative forcing by reflecting solar radiation. SOAs increase the component ratio of scattered light in photosynthetic active radiation （PAR) and the total photosynthesis in canopy layers. They also generate clouds as cloud nuclei and increase precipitation amount in forests. Unfortunately, the concentration of SOAs is very low, and the spatial heterogeneity is very high. This poses a challenge in the evaluation of the spatial distribution of SOAs on a global scale. In contrast, evaluation of spatial and time series variations of BVOCs as precursors of SOAs is easier using an automated thermal desorption gas chromatograph mass spectrometer (ATD-GC/MS) and flux tower network.

Isoprene (C_5H_8, ISO) and monoterpenes ($C_{10}H_{16}$, MTs) are major components of BVOCs. Broadleaf and needle-leaf trees primarily emit ISO and MTs, respectively. Because there are only a few conifers in lower latitude areas, main emission sources of MTs are usually in higher latitude areas. However, actual BVOC concentrations have not yet been simultaneously measured using the same method in multiple forests distributed over a wide area. In particular, seasonal variation in BVOC emissions in forests at different latitudes is not well known.

To address this research gap, we assessed seasonal variation in BVOC concentrations and components about once a month for three years in six forest sites from Hokkaido (LAT 43N) to Okinawa (LAT 26.5N). Despite vegetation differences between coniferous and broadleaf forests, remarkable seasonal variation in ISO and MT concentrations was observed at all sites. The starting temperature of ISO emissions in spring at lower latitudes was lower than that at higher latitudes. The relationship between temperature and MT concentration was closest to the common emission model (Guenther et al.,1993) in the subtropical forests of Okinawa. During winter, trees in the northern areas store MTs in the resin canals of their needle leaves, which might contribute to seasonal variations in MT emission pattern.



P2-T2

NO emission from tropical and polar soils

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NO is one of the trace gases which contributes to the formation of ozone with VOCs and then is one of gases related to global warming. Exchange of NO in ecosystems is important because VOCs are emitted in ecosystems at the same time. Generally, NO is not released from plants but from soils as well as combustion processes such as in vehicles and industrial processes. In soil, NO is emitted from various processes such as nitrification and denitrification processes. However, studies about NO exchanges in ecosystems are quite limited and quantitative estimation of total NO emission is fairly poor because NO is not direct greenhouse gases and in-situ measurements are necessary in the fields because storage of NO in container vessels such as vials or canister is more unstable than greenhouse gases.

In this presentation, we report about soil gas emissions using chamber systems in laboratory to understand more about NO emission from soils.

The target soils were tropical forest soils at Pasoh in Malaysia and polar tundra soils from Ny-Alesund in Spitzbergen, Norway. At Pasoh sites, soils were taken from 4 sites (primary forest, secondary forest, oil-palm plantation, rubber plantation). At Ny-Alesund, soils were taken from active layers at Site3 (Yoshitake et al., 2011).

The soils were sieved by 2mm-mesh-sieve and incubated at 25°C for tropical soils and 5°C for polar soils. The NO soil emissions (the amount of soil is equivalent to 100g of dry soil) were measured at temperatures by controlling incubator temperatures. CO_2 emission (soil respiration) was also measured at the same time.

The tropical soils showed larger emission at primary forest and lower emissions at plantations (Fig.1). The temperature dependence was very similar in NO and CO_2 emissions. The similarity of the temperature dependence plausibly indicates that NO was emitted under nitrification processes. When the soil temperature was controlled from lower to higher temperatures and from higher to lower temperatures, hysteresis in NO emissions were not observed.

The polar soils also showed similar trends as tropical soils in that NO emission is higher in organic soils under plants than mineral soils where lichens are sparsely vegetated in the surface.
When the soil temperature was controlled from lower to higher temperatures (>30°C) and from higher to lower temperatures, hysteresis in NO emissions were observed.

From the results, temperature dependence of soil NO emission should be considered with original climate temperature conditions. In the future, NO soil flux can be modelled using results obtained experimentally as in this study.

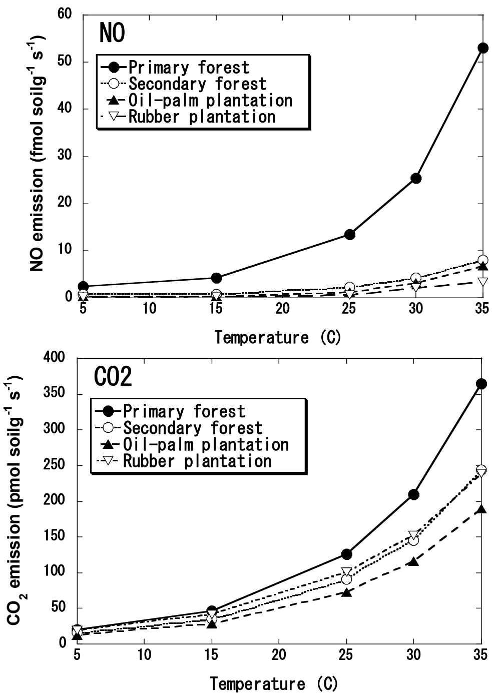

Fig.1 NO and CO_2 emissions from tropical soils

P2-T3

Effect of growth temperature on monoterpene emission rates of *Acer palmatum*

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Biogenic volatile organic compounds (BVOCs) are emitted by vegetation. Isoprene and monoterpenes emitted from trees have important roles in atmospheric chemistry through the formation of secondary organic aerosols and photochemical oxidants. Short-term monoterpene emission from trees is typically dependent on temperature. Since annual mean temperature of the earth is expected to increase in the foreseeable future, growth temperature may be an important factor for predicting monoterpene emissions. To investigate the effect of growth temperature on monoterpene emission rates in broad-leaved trees in Japan, we measured monoterpene emission rate of *Acer palmatum* grown at three different sites among which the annual mean air temperature difference is at most 7 °C.

The study was conducted at Fujiyoshida city (FHK) (annual mean air temperature: 10.6 °C), Gotenba city (GTB) (13.9 °C), and Shizuoka city (SZO) (17.7 °C), Japan. Six mature trees of *A. palmatum* were selected at each site. About 1 m long branches with leaves were sampled for gas exchange measurements. Monoterpene emission were measured with a leaf cuvette method (LI-6400XT, Li-Cor). Monoterpenes were collected in stainless steel adsorbent tubes. Monoterpenes were identified and quantified using a gas chromatography mass spectrometer equipped with a thermal desorption system (ATD-GCMS). To compare the capacity of monoterpene emissions, the emission rates were measured at a standard temperature (30 °C) and a standard PPFD (1000 µmol m^{-2} s^{-1}) (standard emission rate: M_s). Measurements of M_s were conducted once every month in 2018.

In our previous study, monoterpene emission rate of *A. palmatum* depended on both leaf temperature and PPFD. For monoterpene non-storing species, monoterpene emission rate is shown as the temperature and light intensity algorithm (Guenther et al., 1993). $M = M_s \times C_L \times C_T$ …(1)
where M is the monoterpene emission rate. C_L and C_T are temperature and light activity factor, respectively. To obtain annual monoterpene emissions, we calculated the hourly monoterpene emission rates by using the hourly averaged ambient air temperature and PPFD. Except for the measurement days, daily M_s value was estimated by linear interpolation between two neighboring M_s values experimentally determined. We did not measure the PPFD at GTB and FJY sites. The PPFD values were assumed to be the same as that at SZO site.

A. palmatum emitted ten monoterpene compounds. α-Pinene was the dominant (>80%) compound in all cases, except for April at SZO. Figure 1 shows variation in standard monoterpene emission rate (M_s) during the measurement period. After bud break, the M_s at SZO, GTB, and FJY started to increase in early May, middle May, and June, respectively. The highest M_s at FJY, GTB, and SZO were observed during the period from July to August. M_s gradually decreased as leaves of *A. palmatum* became senescent (FJY: late October, GTB: middle November, SZO: early December). The date of start and end of the monoterpene emission was different among the three sites, depending on leaf phenology. However, the highest M_s did not differ among the three sites.

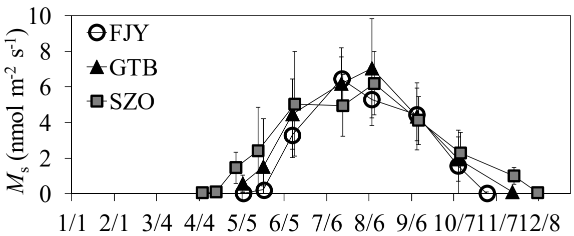

Figure 1. Variation in standard monoterpene emission rate (M_s) in 2018.

The annual monoterpene emissions at FJY, GTB, and SZO in 2018 were calculated to be 10.5, 14.8, and 20.5 mmol m^{-2} $year^{-1}$, respectively. It was found to increase with annual mean air temperature (Figure 2). Our results indicate that global warming might enhance the monoterpene emissions from *A. palmatum*.

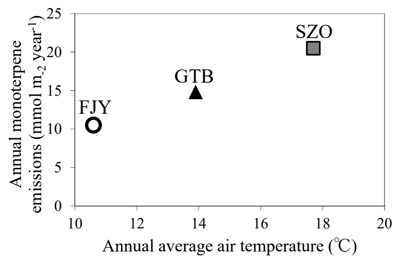

Figure 2. Relationship between annual monoterpene emissions and annual mean air temperature.

P2-E1

The effect of canopy phenology and canopy surface physical phenomena on carbon budget in evergreen coniferous and deciduous broad-leaf forests in a cool-temperate region under ongoing climate change

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Planted evergreen coniferous and natural or secondary deciduous broad-leaf forests are typical vegetation types in Japan. Photosynthetic and respiratory carbon cycle in these forests have multiple ecosystem functions which are responsible for regulating the regional biosphere as well as ecosystem services to local society by providing natural resources and biodiversity. Because of such fundamental importance of these forest types in Japan, quantitative clarification of possible influence of climate change on their carbon cycle and sequestration is one of the highest priorities in ecosystem science in Japan. It is well known in temperate region that ecophysiological and physical processes as well as their phenology are the key regulators of carbon cycling in forest ecosystems. However, it is still unclear how much these canopy processes and resulting carbon sequestration are influenced by climate change. This study aimed to quantify the effect of canopy phenology on carbon budget in evergreen coniferous and deciduous broad-leaf forests in a cool-temperate region under ongoing climate change.

The study was conducted in mountainous region in central Japan, which is influenced by the Asian monsoon, and is characterized by mild, humid springs and autumns, hot, humid summers, and cold, snowy winters.

First, ecosystem model, which can simulate carbon, water and heat cycle, was tuned and validated by using field measurement data at the Takayama evergreen coniferous forest and Takayama deciduous broadleaf forest sites (AsiaFlux TKC and TKY). The simulated seasonal patterns of gross primary production (GPP), ecosystem respiration, and net ecosystem production (NEP) coincided well with those of the tower-flux measurements at both sites. In addition, simulated annual carbon fluxes were similar to those estimated by means of tower flux and biometric measurements at both sites.
Second, to compare the response of the carbon cycle to global warming at both forest types, we simulated carbon cycle under present climate condition (1990-2016) and future climate condition (2070-2096). To reduce the effect of bias error on climate model, we used the difference in air temperature and the ratio for precipitation and solar radiation between the current (MIROC5 historical scenario; 1990-2005) and future projections (MIROC5 RCP2.6 scenario; 2070-2085), instead of using the actual climate model outputs.

The simulated results suggested that the large increased GPP and NEP in evergreen coniferous forest appeared in winter and early spring periods due to early canopy snowmelt and enhanced potential photosynthesis caused by warm winter and early spring, whereas those in deciduous broad-leaf forest appeared in late spring and early summer and autumn periods due to early leaf expansion and late leaf-fall caused by a warm spring and autumn. Consequently, different canopy phenology and canopy surface physical phenomena between both forest types well characterize the sensitivity of carbon cycle to global warming.

P2-E2

Characteristics and Scenarios Projection of NEE Change on the Tibetan Plateau

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14 years of eddy covariance measurements were used to characterize the statistical features of NEE and its relationship with temperature variations during the 14 years. We fitted the Michaelis–Menten equations of the light–response curve to the alpine meadow ecosystem getting the ecosystem-scale light-response curve and then get the relationship between the parameters of the light-response curve and air or soil temperature. Therefore, a statistical model was obtained and by using the statistical model and the scenarios projection of climate change on the Tibetan Plateau, the scenarios projection of NEE changes on the Tibetan Plateau were obtained. The estimate temperature changes with a variation range of 2.3~7.1∘C/100year, the estimate NEE changes firstly increasing of CO2 absorption (from -100.6gC/m2/year to -238gC/m2/year) when the temperature increased below 2°C. However, if the temperature increased over 3°C, this CO2 absorption will be changed to large amount of releases (from -100.6gC/m2/year sink to 263gC/m2/year source when the temperature increased over 5°C).

P2-E3

Quantification of water usages of man-made oasis and natural vegetation in the middle part of Hexi corridor, northwestern China

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Most of the oases in northwestern China's arid regions are located in the deserts and gobies between the Helanshan-Wuqiaoling Mountains and China's western frontier. These oases highly depend on water originating from the mountains of the upper reaches of the inland rivers. Eco-environmental deterioration of these systems began to appear in the middle to late 20th century, and can be linked largely to human activities, which have fundamentally altered the water distribution pattern and circulation processes in arid inland river basins, and became a serious threat to the long-term sustainability of the ecosystems. But few investigations were made to answer even the most basic questions like, what degree of vegetation recovery would be optimal? The issues of how to balance the need for water in agriculture and nature, and achieve the twin goals of food and environmental security are still open and turning out to be a major challenge in the arid inland river basins, e.g. revegetation in degraded alpine ecosystem of the upper river basins may reduce the runoff released to downstream drainages, and affect water security for food production in oasis agriculture of the middle river basins. Taking the plain oasis in the middle reaches of the Heihe River Basin, one of the largest inland river basins in northwest China, as an example, we estimated the water uses of irrigated agriculture and natural vegetation, and then analyze the water security issues facing the ecosystem and discuss potential solutions. Our results show that the evapotranspiration of human-planted shelter forest could be as high as 620 $mm \cdot yr^{-1}$, and the total water consumption keeps around 738 $mm \cdot yr^{-1}$. The water consumption of agricultural land in desert oasis varied between 630-675 $mm \cdot yr^{-1}$at field scale, ~ 960 $mm \cdot yr^{-1}$ at irrigation-unit scale, and 650 $mm \cdot yr^{-1}$ at oasis scale. About 9600 m^3 of water resources are needed to maintain one-hectare oases, which takes up about 25% of total water available at irrigation unit scale or 22% at oasis scale in this region. A considerable part of it goes to shelter system, i.e. 12.4% and 18% of total water available at irrigation unit scale and oasis scale, respectively. Our calculation suggests that the oasis in middle HRB at the current water-use patterns is at a quasi-stable state, and almost approaching the threshold of instable.

P2-E4

The variation of carbon dioxide flux and response to the water level changes over a large ephemeral lake

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Carbon flux has been more intensely studied over land surfaces, while, a large proportion of lakes have either been neglected or parameterized with simple bulk approaches. Several studies have suggested that most lakes are net carbon sources to the atmosphere rather than carbon sinks. Quantifying and understanding the environmental drivers of carbon dioxide (CO2) flux from lakes is important in order to have a better understanding of the greenhouse-gas budget of aquatic systems and the global ecosystem. Poyang Lake is the largest freshwater lake in China. It is considered as an ephemeral lake – experiencing dynamic seasonal transitions ranging from a lake surface to wetland conditions. In this study, we use the eddy covariance technique to explore the diurnal and seasonal variation patterns of CO2 flux of Poyang Lake during lake-covered and wetland-covered periods from August 2013 to July 2016. Footprint analysis was used to separate CO2 flux observations into the lake surface and wetland surface according to the underlying surface, and two sophisticated surface models were used to derive gap-free time series. Observations and footprint integrated simulations compared well, even for situations with flux contributions including grassland and lake. Poyang Lake plays the role of carbon source during the lake-covered period, while it acts as a clear carbon sink due to the photosynthesis of vegetation during the wetland-covered period. The annual CO2 flux over Poyang Lake, finally, shows a carbon sink, ranging from -31 to -54 $gCm^{-2}a^{-1}$. The magnitude of carbon sink in annual scale is affected not only by meteorological factors but also by the change of water level.

Hydraulic characteristics and water storage of Japanese cypress using sap flow rate and water potential measurements

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Hydraulic characteristics and water storage in a 60-yr-old Japanese cypress tree (*Chamaecyparis obtuse* Sieb. Et Zucc) were studied in the Kiryu Experimental Watershed (AsiaFlux KEW site), located in Shiga Prefecture, central Japan. To investigate daily water use, water potentials of soil (10 cm in depth, Ψ_S), root (Ψ_R), basal stem (1 m, Ψ_{STB}), upper stem (20 m, Ψ_{STU}), primary branch (20 m, Ψ_{PB}) lateral branch (20 m, Ψ_{LB}), and leaf (20 m, Ψ_{LF}) and sap flow rate at the base (1 m, u_B) and the upper (20 m, u_U) of the stem were measured. Transpiration rate (E) in mature leaves at 20 m and latent heat flux (LHF) was also measured during the measurement period. According to Ohm's Law, hydraulic conductance (K) between the organs in a soil-plant-atmosphere continuum (SPAC) was estimated from transpiration rate (E) and the difference in water potential between the adjacent organs ($\Delta\Psi$) as: $K = E / \Delta\Psi$.

Hydraulic conductance (K) was the highest between lateral branch and leaf ($K_{LB\text{-}L}$), next-highest between basal stem and upper stem ($K_{STB\text{-}STU}$), next-highest between root and basal stem ($K_{R\text{-}STB}$), and the lowest between upper stem and lateral branch ($K_{STU\text{-}LB}$, Fig. 1). Latent heat flux (LHF) started to increase with increasing VPD in the morning and stopped in the evening about 1 h earlier than water flow in the upper stem (compare Fig. 2A and black line in Fig. 2B or 2C). The clear time lag between u_U and u_B (Fig. 2B) and that between Ψ_{STU} and Ψ_{STB} (Fig. 2C) was also observed in the morning and evening, ranging about 1.5-2 h. Although LHF, sap flow rate (u_U, u_B) and water potential (Ψ_{STU}, Ψ_{STB}) reached their peak at the same time (around 13:30), time course of each parameter was different (Fig. 2). Such differences in the morning suggested that water stored in leaves and/or stems was utilized for transpiration in early morning before water uptake from the soil, and those in the evening suggested that water was recharged to internal storage.

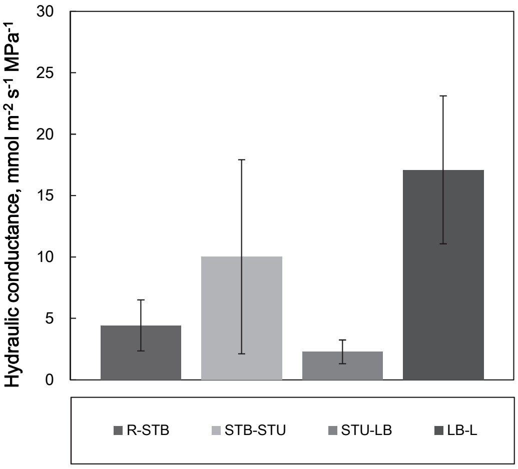

Fig. 1 Hydraulic conductance (K) between the organs in a SPAC.

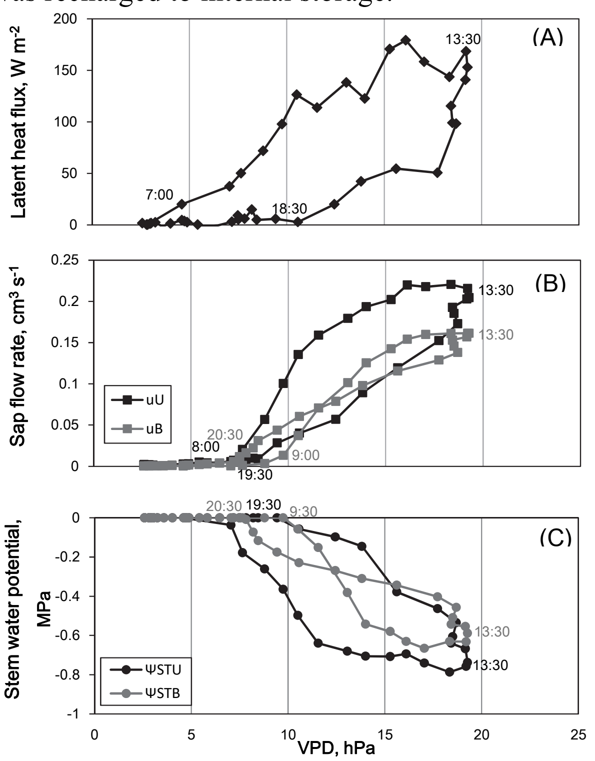

Fig. 2 The relation (A) between VPD and LHF, (B) between VPD and sap flow rate of the upper and basal stem (u_U, u_B) and (C) water potential of the upper and basal stem (Ψ_{STU}, Ψ_{STB}).

P2-E6

Contribution of whole-tree water storage to daily transpiration in conifer trees

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In this study, we quantified daily course in foliage, sapwood, and bark water storage and their contribution to transpiration in whole-trees of *Cryptomeria japonica* and *Chamaecyparis obtusa*. Three study trees were selected in each species (height = 6 – 8 m, DBH = 6 – 9 cm). *C. japonica* was planted at the experiment field in Kyusyu University located in Fukuoka Prefecture, southern Japan and *C. obtusa* was planted at in the Kiryu Experimental Watershed (AsiaFlux KEW site) located in Shiga Prefecture, central Japan. First, we measured diurnal changes in transpiration rate, sap-flow velocity and stem radius on a sunny day. On the next sunny day, all study trees were cut while suspended from scaffolding and the cut base was immediately submerged and recut in a bucket filled with water. To estimate whole-tree cumulative daily transpiration (ΣT_{Tree}, ml day^{-1}), the transpired water was replenished every 0.5 – 1 hr. Then whole-tree transpiration rate (T_{Tree}, ml hr^{-1}) were calculated combined the diurnal changes in shoot transpiration rate. We also combined these measurements with whole-tree pressure–volume (WTPV) analysis to show how water stored in foliage, sapwood, and bark were depleted and replenished during the course of a sunny day. The hourly rate of change in whole –tree water storage (P_{Tree}, ml hr^{-1}) was assumed by calculating the sum of hourly change in water storage of each organ. Then we calculated the rate of contribution for whole-tree cumulative daily water storage (ΣP_{Tree}, ml day^{-1}) to ΣT_{Tree}. These experiments were conducted in August for *C. japonica* and in October for *C. obtusa*.

The rate of contribution for ΣP_{Tree} to ΣT_{Tree} were around 10 % in *C. japonica* and around 20 % in *C. obtusa*. A little different of these results between species could be related by difference of ΣT_{Tree} due to seasonal variation. In both species, foliage contributed the most (around 65 %) to ΣP_{Tree}, and sapwood contributed around 35 %, while contribution of bark was around 5 %. During the course of the day, P_{Tree} showed greater contribution to T_{Tree} in the morning when transpiration started and increased, while after transpiration decreased, P_{Tree} increased by refilling of water during the night (Fig 1). These results suggested the importance of leaf water storage in maintaining daily transpiration in conifer trees.

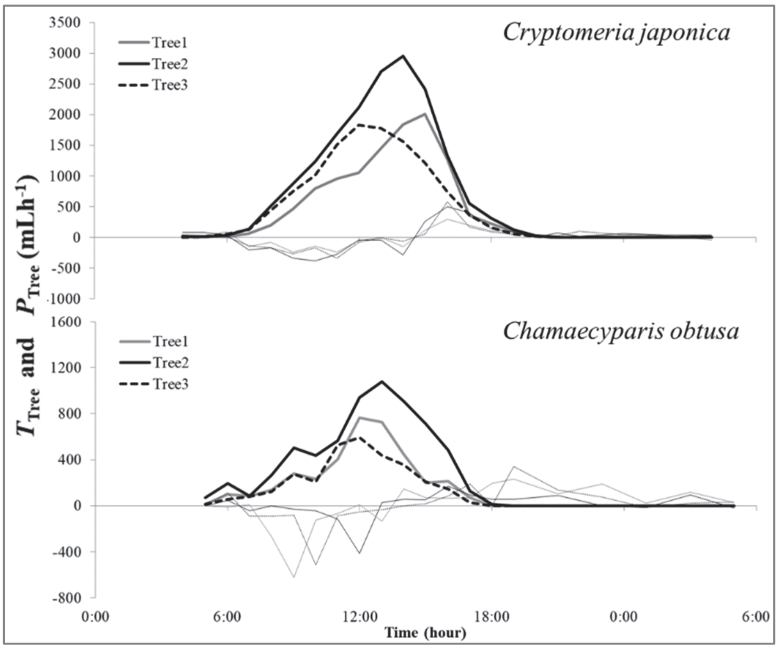

Fig 1. Hourly change in whole-tree transpiration (T_{Tree}, ml hr^{-1}, thick lines) and water storage (P_{Tree}, ml hr^{-1}, narrow lines). Increase of T_{Tree} represents water loss by transpiration, while decrease of P_{Tree} represents contribution of water storage.

P2-E7

Long-term soil warming effect on insect-plant interactions at the canopy of tall oak trees

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Short-term experiments cannot detect whether warming effects vary with time. Besides, it is difficult to extrapolate the results of small-scale experiments to actual global changes owing to "lamp effect". To avoid these limitations, long-term warming experiments with large-spatial scale are necessary. Previous studies have showed plant-mediated effects of global warming on herbivore insects. They focused on leaf traits (leaf susceptibility) as important determinant of herbivory (leaf damage). In addition, cumulative effects of warming due to shift in insect community composition may play another important role to determine herbivory because insect community composition may be related to herbivore pressure. Combining changes in leaf susceptibility (leaf traits) and herbivore pressure (insect community composition) should be considered for better understanding the mechanism of temporal variation in the magnitude of warming effect on herbivory. In this study, we report results of 9-year (2007-2015) soil warming experiment of tall oak trees *Quercus crispula* (18-20 m in height) to determine how long-term soil warming affect insect-plant interactions at the canopy of tall oak trees. We have three questions: 1) How do leaf traits and herbivory respond to long-term soil warming? 2) How does the magnitude of soil warming effect on leaf traits and herbivory vary temporally? 3) Which leaf traits are responsible for the observed variation in herbivory?

P2-R1

The temporal variation of Solar Induced Fluorescence detected by the canopy spectroscopy in cool-temperate broadleaf deciduous forest in central Japan

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Solar Induced Fluorescence (SIF) is recognized as a new remote sensing index to indicate the photosynthetic capacity, including gross primary productivity (GPP) of terrestrial ecosystems (*Meroni et al*., 2009). The correlation between SIF and GPP has been detected by the satellite-based measurement (e.g. GOSAT; *Frankenberg et al*., 2011) and by eddy flux tower-based one in recent studies (e.g. *Damm et al*., 2015). To understand mechanism of its correlation and to validate the satellite SIF measurement, ground based observation is necessary to cover the long time period and diverse ecosystem types. Among the multiple eddy flux sites that started monitoring the SIF covering ecosystem types recently in Japan, Takayama deciduous forest (TKY; 36.146°N, 137.42°E) was one of the oldest CO_2 flux (i.e. GPP) measurement in Japan (*Muraoka et al*., 2015). Low resolution spectroradiometer MS-700 (Eko Instruments, Tokyo, Japan) with 3.3 nm of the full-width at half maximum (FWHM) and fish-eye time-lapse camera has been installed at the top of the tower as a part of Phenological Eyes Network; PEN (*Nasahara and Nagai*, 2015).

We set high-resolution spectroradiometers (HR4000 and QEpro, Ocean Optics, Dunedin, FL, USA) with 0.060-0.17 nm of FWHM to measure radiation values for SIF detection at TKY site on April 21th, 2018 and March 14th, 2019, respectively. Spectrometers were equipped of 7 optical fiber cables via optical fiber switch and measured the upward and downward spectra at three heights: 8, 14, and 18m (canopy top) with field of view (FOV) of 180°, and downward spectrum in 45° angle with FOV of 25°). SIF (denoted as $F(\lambda)$) was calculated from the incoming solar and reflected spectra in the O_2-A absorption band by spectral fitting method (SFM; *Meroni et al*., 2009) as below:

$$L(\lambda) = \frac{r(\lambda)E(\lambda)}{\pi} + F(\lambda) \quad (1)$$

where L(λ) is radiance upwelling from vegetation, $r(\lambda)$ is reflectance, and E(λ) is incident irradiance. Following the method of *Yang et al*. (2015), we assumed that both $r(\lambda)$ and $F(\lambda)$ are the linear functions of λ in O_2-A absorption band around 760 nm. The relationship of normalized vegetation index (NDVI), enhanced vegetation index (EVI), photochemical reflectance index (PRI) and photosynthetically active radiation (PAR) to SIF variability were also discussed among different leaf area, photochemical state and incident radiation. Hemispherical fisheye camera and irradiance of MS-700 were compared to check the effective SIF detection under various sky conditions.

The aim of this research is to develop the stable continuous measurement of ground-based SIF to investigate photosynthetic processes and GPP in the forest ecosystem. In the study, we focused on the detection of temporal SIF variability in O_2-A band to examine its' reliability as a stable indicator of such as GPP and we introduce the preliminary result of the SIF detection for the growing season in 2018 and 2019. We may also discuss the technical issues in observation of SIF emission from multiple canopy layers.

P2-R2

High temporal monitoring of terrestrial CO_2 fluxes using geostationary satellites

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New generation geostationary satellites such as Himawari-8 AHI provide high temporal resolution observation (e.g., 10 min) with multiple spectral bands and moderate spatial resolution. Therefore, such geostationary satellites provide new and novel datasets for terrestrial vegetation monitoring. Land surface reflectances and land surface temperature are key variables for vegetation monitoring. In this study, we will show our efforts on the application of Himawari-8 AHI data to terrestrial vegetation monitoring. First, we demonstrate that surface reflectances estimated from original Himawari-8 datasets (i.e., top of atmosphere reflectance) can monitor vegetation with higher temporal resolutions. Compared with commonly-used polar-orbiting satellite/sensors (e.g., Terra MODIS), cloud-free observation data were drastically increased. Combining surface reflectances and land surface temperatures, terrestrial energy, water, and CO_2 fluxes can be also estimated using machine learning techniques by extending existing studies [e.g., Ichii et al., 2017]. However, one difficulty is to collect recent AsiaFlux observation datasets. Since Himawari-8 AHI data are available after July 2015, recent AsiaFlux observation datasets are highly required, and collaboration with AsiaFlux data providers is highly welcome and appreciated.

References

Ichii *et al.* (2017) New data-driven estimation of terrestrial CO_2 fluxes in Asia using a standardized database of eddy covariance measurements, remote sensing data, and support vector regression. Journal of Geophysical Research Biogeosciences. 122, 767–795, doi:10.1002/2016JG003640.

P2-R3

Estimation of carbon dioxide emissions through tropical peatland subsidence using interferometric synthetic aperture radar analysis

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Greenhouse gas emissions associated with land use change are attracting more attention in forested peatlands in Southeast Asia, which had accumulated a huge amount of soil carbon. The tropical peatlands have been deforested by the rapid expansion of oil palm plantations in Borneo. As a result of drainage, land subsidence occurs through a series of steps of compaction, shrinkage, consolidation, and oxidative peat decomposition. Carbon dioxide (CO_2) is emitted through the peat decomposition. The CO_2 emissions have been estimated from manually-measured subsidence using peat properties, such as bulk density and carbon content, and an empirical factor to separate total subsidence into physical and decomposition fractions.

We estimated large-scale subsidence of a newly-developed oil palm plantation from a peat swamp forest in Sarawak, Malaysia, using C-band Synthetic Aperture Radar (SAR) data of Sentinel-1A operated by ESA. Two time-series data at intervals of 12 days were used to detect the displacement of the scattering objects (ground surface) by interferometric SAR (InSAR) processing with SNAP software. The analysis of ground displacement (subsidence) was made for approximately nine months from 7 August 2017 to 28 April 2018. CO_2 emissions through the subsidence were estimated by multiplying the subsidence depth by peat bulk density of 0.1 Mg m^{-3}, peat carbon content of 52.8 % (Ishikura et al., 2018), and the contribution rate of oxidative peat decomposition at 50 %.

Figure 1 presents the average ground displacement every 12 days from 7 August 2017. Precipitation was from the Global Precipitation Measurement (GPM) and shown as 12-day-long amount to overlap with the C-band SAR observation timing. Figure 2 provides the distribution map of the final displacement results for the study area of 2143 ha in the black frame. The ground subsidence was the subsidence was 3.2 cm for 8.5 months on average, from which annul subsidence was roughly estimated to be 4.3 cm year^{-1}. In addition, CO_2 emissions through the subsidence was calculated to be 31.3 t CO_2 ha^{-1}; annual emission was 41.8 t CO_2 ha^{-1} year^{-1}. This result was much less than 145.5 t CO_2 ha^{-1} year^{-1} of Hayashi et al. (2019), 66 t CO_2 ha^{-1} year^{-1} of Couwenberg and Hooijer. (2013) and 178 t CO_2 ha^{-1} year^{-1} of Hooijer et al. (2012). No significant correlation was found between ground displacement and precipitation ($p > 0.05$).

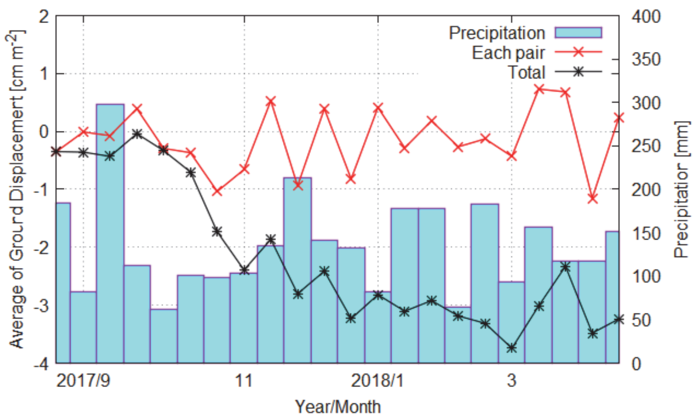

Figure 1. Ground displacement by InSAR processing. Red-line is displacement every two time-series. Black-line indicates total displacement, and light blue bars are precipitation.

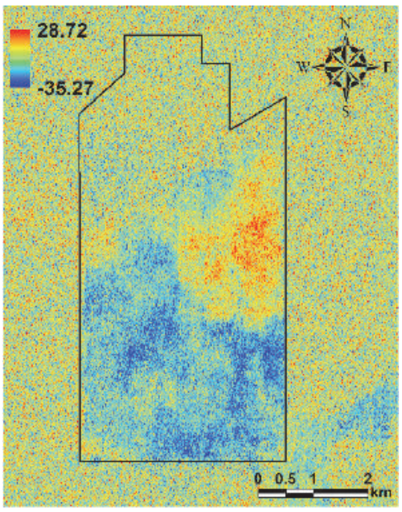

Figure 2. The distribution of total ground displacement (cm). Blue indicates subsidence, red means uplift, and the target region is in black.

P2-R4

Measuring landscape albedo using unmanned aerial vehicles

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Surface albedo is a critical parameter in surface energy balance and albedo change is an important driver of changes in local climate. In this study, we developed a workflow for landscape albedo estimation using images acquired with a consumer-grade camera on board unmanned aerial vehicles (UAVs). Flight experiments were conducted at two sites in Connecticut, U. S. A. and the UAV-derived albedo was compared with the albedo obtained from a Landsat image acquired at about the same time of the UAV experiments. We find that the UAV estimate of visible-band albedo of an urban playground (0.037 ± 0.063, mean ± standard deviation of pixel values) under clear sky conditions agrees reasonably well with the estimate based on the Landsat image (0.047 ± 0.012). But because the cameras could only measure reflectance in three visible bands (blue, green, and red), the agreement is poor for shortwave albedo. We suggest that deployment of a camera capable of detecting reflectance at a near-infrared waveband should improve the accuracy of shortwave albedo estimation.

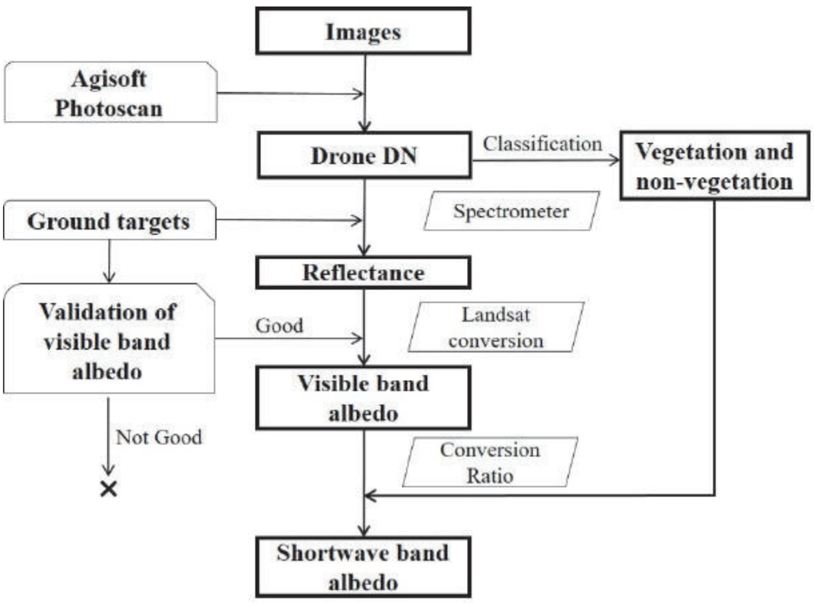

Figure 1. Workflow for estimating landscape visible and shortwave band albedo

P2-R5

High-Frequency estimation of the land surface temperature using next-generation geostationary satellite data

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Land surface temperature (LST) is a key parameter of land-atmosphere interaction on various scales. Therefore, the LST has potential applications in various fields, such as the surface energy balance (sensible/latent heat and evaporation), vegetation monitoring, urban heat island, and environmental studies, amongst others. Since satellite observations can provide LST data over a wide area with homogeneous quality, LST retrieval algorithms have been proposed for various sensors.

We present a new LST retrieval algorithm utilizing multi-bands of Himawari-8 sensor (Yamamoto et al., 2018). Himawari-8 is a new generation of Japanese geostationary meteorological satellite, which began the observations on July 2015. The algorithm requires brightness temperatures and land surface emissivities of the thermal infrared (TIR) bands (centered at 10.4, 11.2 and 12.4 µm) of Himawari-8. The brightness temperature data of Himawari-8 were provided by the Center for Environmental Remote Sensing, Chiba University, whereas the land surface emissivities were estimated by a semi-empirical method based on the land cover classification information and the normalized difference vegetation index (Yamamoto and Ishikawa, 2018). LST retrieval was limited to a clear-sky condition where the upward thermal infrared radiance from the land surface can be observed by the Himawari-8 sensor. The spatial and temporal resolutions of the retrieved LST data were 0.02° and 10 min, respectively.

Figure 1 shows an example output of our developed LST retrieval algorithm. This LST product has been sufficiently verified using simulation data, but further validation using in-situ LST that can be estimated from longwave radiation flux observations is insufficient, which is a future issue.

Yamamoto, Y., and H. Ishikawa, 2018: Thermal land surface emissivity for retrieving land surface temperature from Himawari-8. *J. Meteor. Soc. Japan*, **96B**, 43–58.
Yamamoto, Y., H. Ishikawa, Y. Oku, and Z. Hu, 2018: An algorithm for land surface temperature retrieval using three thermal infrared bands of Himawari-8. *J. Meteor. Soc. Japan*, **96B**, 59–76.

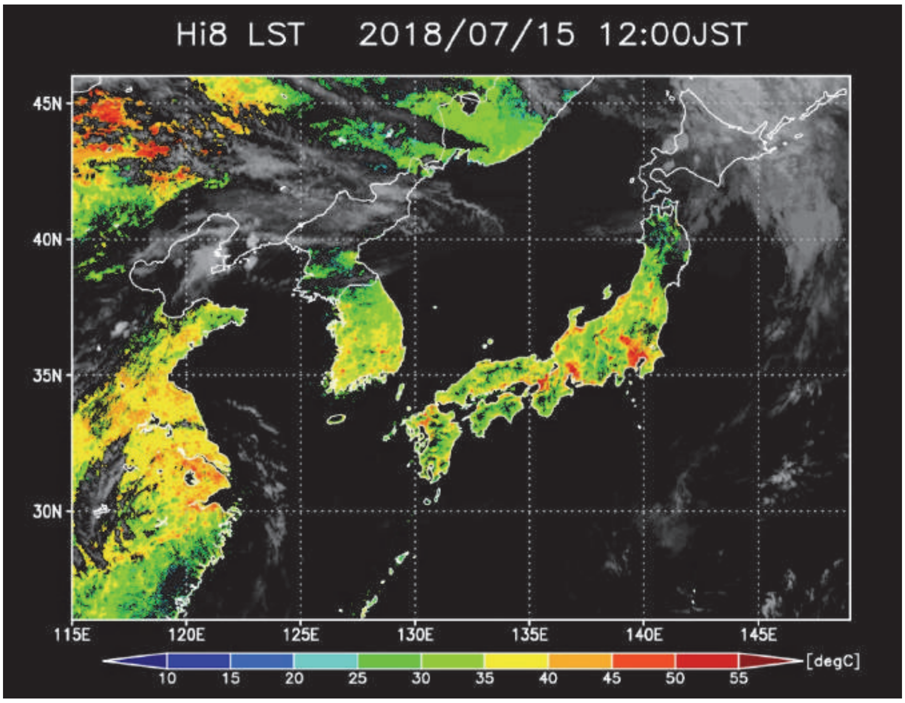

Figure 1. An example output of LST distribution over East Asia at 03:00UTC, 15 July 2018. Background image is an infrared image of Himawari-8 sensor.

P2-R6

GPP capacity estimation algorithm using light response curve in various vegetation types for global observing satellite data

Kanako Muramatsu[1], Emi Yoneda[1], Akari Ozaki[1], Noriko Soyama[2]
1 Nara Women's Univ., Nara, Japan
2 Tenri Univ., Nara, Japan

An algorithm to estimate gross primary production (GPP) capacity from global satellite data was developed using flux data. The characteristic of this method corresponds to photosynthesis process. The photosynthesis velocity depends on photosynthesis capacity and depression because of weather conditions. It was assumed that the capacity part depends on one of plant physiological parameters of chlorophyll contents of a leaf. In the previous study (J. Thanyapraneedkul et al., 2013), the framework of estimation method using light-response curve was developed. The two parameters of light-response curve of the maximum of GPP capacity in the light saturation and relating on the initial slope were determined. The parameter relating on an initial slope was used as fixed values for each vegetation types. The maximum of GPP capacity at the light saturation was determined from the linear relationship between GPP capacity at 2000 (μmolm^{-2}s^{-1}) and Chlorophyll index (CI_{green}) using green band developed by Gitelson et al. (1996). The relationship determined of open shrublands (US-Ses), savanna (US-Wjs), grass (CA-Let), corps of rice paddy (JP-MSE), deciduous broadleaf forests (JP-TKY), permanent wet (US-Los (DOI : 10.17190 / AMF / 1246071)) and deciduous needleleaf forests (JP-TMK), evergreen needleleaf forests (JP-FJY) and evergreen broadleaf forests (TH-SKR) (J. Thanyapraneedkul et al., 2013; Mineshita et al., 2016; Muramatsu et al., 2017).

The total forest area is 31% of total land area in 2010 (FAO Forest paper), and Europe including the Russian Federation occupies 25% of the world's total forest area. The kinds of forest are rich as deciduous forest, evergreen needleleaf and broadleaf forest in Europe. Especially, the forest grows on permafrost in eastern Siberia, Russia. It is special characteristics in Siberia. For applying the method worldwide, the parameter estimation method should be studied in another continent for the same vegetation types.

The method needs the vegetation types for estimating GPP capacity. Detailed vegetation type classification is impossible when the spectral reflectance pattern is similar each other. The miss-classified results cause errors of GPP capacity estimation.

The purpose of this study was to evaluate applicability of this algorithm to Europe including Siberia using flux data and MODIS reflectance data of clear pixel, and how vegetation types were divided into groups from the view point of parameter estimation formula in light-response curve.

The relationships between GPP capacity at 2000 from flux data and CI_{green} from MODIS were studied. Flux data of open shrublands (ES-Agu), deciduous broadleaf forests (FR-Hes), evergreen needleleaf forests (NL-Loo, IT-Lav, YPF), and evergreen broadleaf forests (FR-Pue), deciduous needleleaf forests (YLF) were used together with the previous study sites. The relationship of the same vegetation type had on the same slope line, even if continental were different. And the relationship was divided into five groups. One was open shrublands, savanna, grasslands, croplands of rice paddy, second deciduous broadleaf forest, and permanent wetlands, third deciduous needleleaf forests, forth evergreen needleleaf forest, fifth evergreen broadleaf forests. The slope difference for each vegetation type and light-response curve initial slope were discussed in the conference.

P2-R7

Phenological changes in *in-situ* and GOSAT-based SIF in evergreen coniferous forest in Japan

Hibiki M. Noda[*1], Yoshiko Kosugi[2], Kouki Hikosaka[3], Yukio Yoshida[1], Haruki Oshio[1]
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2 Kyoto University, Kyoto, Japan
3 Tohoku University, Sendai, Japan

In temperate region, CO_2 flux of terrestrial vegetation shows significant seasonal change because of the seasonal changes in meteorological conditions, e.g., radiation, precipitation and temperature and phenological changes in canopy structure and physiological traits of plant species. To monitor the vegetation phenology, optical remote sensing is a powerful tool. In a temperate deciduous forest, vegetation indices, such as NDVI (Normalized Difference Vegetation Index) and EVI (Enhanced Vegetation Index) have been utilized to observe the canopy phenology. However, since those indices are mainly determined by LAI (leaf area index), it is difficult to observe phenology of evergreen forest, which shows very little change in the canopy structure throughout a year. Recently new optical index SIF (solar induced chlorophyll fluorescence) has been utilized to understand the temporal and spatial variations in the photosynthetic activity and/or production. Since the chlorophyll fluorescence is a radiation emitted by photosynthetic process itself, SIF is thought to be directly linked to photosynthetic activity. So, SIF would be available to monitor phenology of evergreen species.

In present study, we have examined seasonal changes in in-situ and satellite-based SIF in evergreen coniferous forest in Japan. In-situ SIF measurement was conducted at Kiryu Experiment Watershed ("Kiryu site"), dominated by Japanese cypress (*Chamaecyparis obtusa*). Japanese cypress forest is pne of very common vegetation types in Japan. Kiryu site is one of AsiaFlux site and flux measurement by eddy covariance methods have been conducted. We started continuous measurement of in-situ SIF measurement at the site from the end of March 2017. In-situ SIF of Kiryu site shows similar seasonal pattern with GPP; increase from sprig to summer and decrease autumn to winter. In present study, we will discuss the phenological changes in the relationship between GPP and SIF in Kiryu site. We also show the seasonality of satellite-based SIF retrieved from by GOSAT data in around Kiryu site, mainly dominated by evergreen coniferous trees.

P2-R8

Ground based measurements of aerosol properties for estimating biophysical parameters by using optical Earth observation data

Hirokazu Yamamoto[*1], Satoshi Tsuchida[1] , Koki Iwao[1] , and Hiroki Mizuochi[1]
1 Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan.

Many satellite-based optical Earth observations have provided higher-level products related with various biophysical parameters. Most of higher-level products need the land surface reflectance observed by satellite sensor, which is a key role dataset for higher-level products such as LAI, Land cover, NPP/GPP, and so on. The land surface reflectance product is derived from TOA radiance/reflectance product by applying the atmospheric correction algorithm, which removes the atmospheric effects of absorption, scattering, and transmission. Validation of this product is also very important due to the accuracy of higher-level products related with biophysical parameters.

The validation data obtained over the sites called Phenological Eyes Network (PEN) in Japan would be useful, and we have three validation sites for ground-based measurement of atmospheric parameters in Japan. Skyradiometer POM02 manufactured by PREDE Co., Ltd. to measure the atmospheric parameters over three validation sites, and POM02 can derive various parameters of the aerosol optical properties, which include the aerosol optical thickness (AOT), single scattered albedo (SSA), Angstrom exponent (AE), Refractive indices (RefRe, RefIm), the aerosol volume size distribution.

In this research, we show the long-term measurement results of the aerosol optical properties over each validation site, and discuss the effects for the land surface reflectance derived from satellite optical sensors.

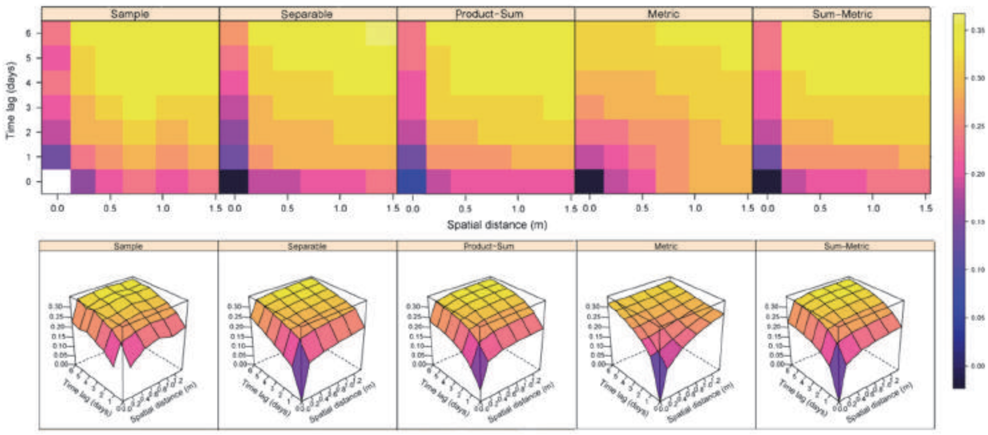
P2-M1

Spatio-temporal variability in N_2O emissions from a tea-planted soil in subtropical central China

Xinliang Liu*[1], Yong Li[1], Xiaoqing Fu[1], Jianlin Shen[1], Yi Wang[1] and Jinshui Wu

1 Key Laboratory of Agro-ecological Processes in Subtropical Region and Changsha Research Station for Agricultural & Environmental Monitoring, Institute of Subtropical Agriculture, Chinese Academy of Sciences, Hunan, China

To explore the intrinsic spatial patterns of N_2O emissions in agricultural systems, not only should the spatial and temporal variability in N_2O emissions be analyzed separately, but the joint spatio-temporal variability should also be explored by applying state-of-the-art spatio-temporal semivariogram models and interpolation methods. We evaluate the spatio-temporal variability of N_2O emissions from tea-planted soils in subtropical central China and compare the prediction performances among four spatio-temporal variogram models, i.e., the separable, product-sum, metric and sum-metric model. Then, we assess the accuracy of the traditional in *situ* static chamber observation methods by comparison with spatio-temporal regression interpolation. We examined the spatio-temporal variability in N_2O emissions from a tea-planted soil from 28 April 2014 to 27 May 2014 using 96 static mini chambers in an approximately regular grid on a 40 m^2 tea field (sampling 30 times), and the results were compared with the long-term observation of N_2O emissions using large static chambers (sampling 5 times). The N_2O fluxes exhibited strong spatial, temporal and joint spatio-temporal autocorrelation on effective ranges of spatial and temporal dependence, i.e., 0.41 m and 5.4 days, respectively. The predictions of the kriging interpolations for the total N_2O were approximately 25% higher than the measurements of the long-term observation. Our results indicate that the long-term observation of N_2O emissions from tea fields should be carried out in a higher density sampling experiment, in which the spatial and temporal sampling intervals should be adjusted to improve the accuracy of the N_2O flux estimates.



Rubber yield estimation using net ecosystem production (NEP)

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1 Center of Thai-French Cooperation on Higher Education and Research, Kasetsart University, Bangkok, Thailand
2 UMR Eco&Sols, CIRAD, Montpellier, France
3 Faculty of Agriculture, Kasetsart University, Bangkok, Thailand

Latex yield estimation using Eddy Covariance-based methods are of interest for rubber plantation monitoring. We use eddy covariance technique to measure the net primary production (NEP) which is the net ecosystem exchange (NEE, the vertical net flux of CO_2 above the rubber plantation). NEP of a 19-year old, latex-producing rubber plantation of a monoclonal stand of rubber trees (*Hevea brasiliensis* Müll.Arg.) clone RRIM 600 at Chachoengsao Rubber Research Center, Chachoengsao province, Thailand was observed for 5 years, starting from 2013. The results showed that NEP from 2013 to 2017 ranged from 7.65 to 18.35 tons C ha^{-1} year^{-1} and averaged 10.78 tons C ha^{-1} year^{-1}. The latex yield ranged 1.44 to 2.36 tons ha^{-1} year^{-1} and averaged 2.05 tons ha^{-1} year^{-1}. In addition, NEP was positively related to annual latex yield and explained 64.9% of its variation (Figure 1). This refers that we can use accumulated NEP over the growing season to estimate latex yield.

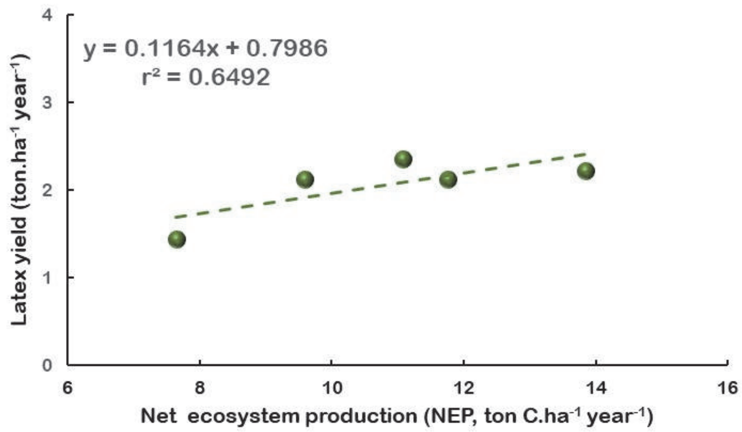

Figure 1 Relationships between latex yield (ton.ha^{-1}year^{-1}) and Net ecosystem production (NEP, ton C.ha^{-1}year^{-1}).

P2-M3

A global carbon cycle model system for the GOSAT-2 project

Makoto Saito[*1], Yosuke Niwa[1], Daisuke Goto[1], Tazu Saeki[1], Kazutaka Murakami[1], Richao Cong[1], Tatsuya Miyauchi[1], Tomohiro Shiraishi[1], Ryuichi Hirata[1], Yukio Yoshida[1], and Tsuneo Matsunaga[1]
1 National Institute for Environmental Studies, Tsukuba, Japan

The Greenhouse gases Observing SATellite 2 (GOSAT-2) was launched, as the successor of GOSAT, on 29th October 2018 into a sun-synchronous orbit at an altitude of 613 km with 6-day revisit cycle. GOSAT-2 is designed to measure atmospheric carbon dioxide (CO_2), methane (CH_4) and carbon monoxide (CO) with two instruments: The Thermal And Near-infrared Sensor for carbon Observation Fourier Transform Spectrometer 2 (TANSO-FTS-2) and the Cloud and Aerosol Imager 2 (TANSO-CAI-2). The GOSAT-2 mission inherits the main objective of the GOSAT that improves our knowledge of spatiotemporal variations of CO_2 and CH_4 in the atmosphere and the process governing their exchange between the atmosphere and the Earth's surface and contributes climate change studies and related environmental policy making. The GOSAT-2 project is planning to provide the data products based on GOSAT-2 observations, following the GOSAT project, which provides the data products with four processing levels; Level 1 provides radiance spectral data, Level 2 atmospheric concentration data, Level 3 atmospheric concentration map data, and Level 4 global surface flux data, respectively. Among the data products, Level 2 and Level 4 products using TANSO-FTS-2 observations need model estimates in their processing. Global distribution estimates of atmospheric CO_2, CH_4, and aerosol using atmospheric transport models are used as prior information in Level 2 products, and Level 4 products are model estimates using an atmospheric transport model and inversion system with prior model information on terrestrial biosphere and ocean fluxes, anthropogenic emissions, biomass burning, and so on. The GOSAT-2 project develops these models and constructs a global carbon cycle model system for regular operation of the data products. We are showing an overview of the model system in AsiaFlux Workshop.

P2-M4

Effects of mortality in a long-term carbon budget modeling

Katsumi Yamanoi*[1] and Yasuko Mizoguchi[1]
1 Hokkaido Research Center, Forestry and Forest Products Research Institute, Hokkaido, Japan.

The carbon budget for a decidual broadleaf forest has be observing in the Sapporo forest meteorology research site (SAP). The forest was damaged by a severe wind-throw disturbance in 2004. More than 40% trees died and supplied to forest floor as coarse wood debris (Fig. 1). The mortality increased after the disturbance, and then vary over the years (Fig. 2). In a long-term modeling, the mortality was an important factor for carbon budget along with global warming. We assumed constant and decline mortality by the end of the century (Fig. 3). As the warming pathways, we set three scenarios (RCP 2.6, RCP 4.5 and RCP 8.5). Using the ecological process model, we predicted future carbon budget and regrowth of the forest.

Fig. 4 shows carbon flux and storage for a decline mortality and RCP 4.5 pathway. After the disturbance, gross primary production was greatly decreased, whereas respiration was maintained. Both were increased over the years. As a result, net ecosystem production was negative over 15 years. Under positive NEP, biomass was clearly increased. Nevertheless, it takes 40 years to return the same biomass after the disturbance. The mortality will affect carbon budget and regrowth rate. We verify calculations for several conditions.

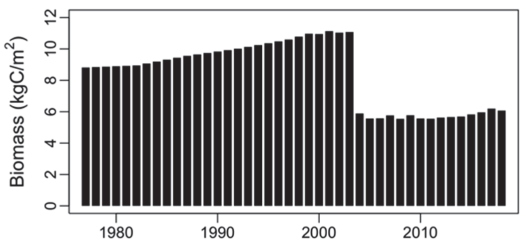

Fig. 1 Biomass change from 1977 to 2018. in SAP site.

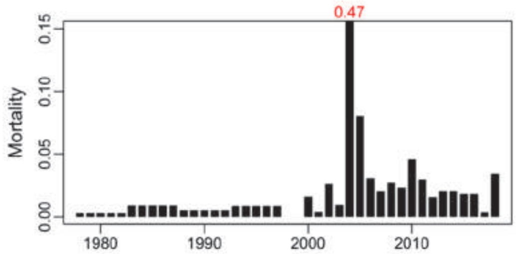

Fig. 2 Mortality change from 1977 to 2018 in SAP site.

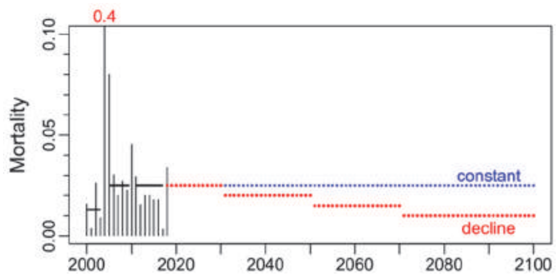

Fig. 3 The assumption of mortality for the modeling.

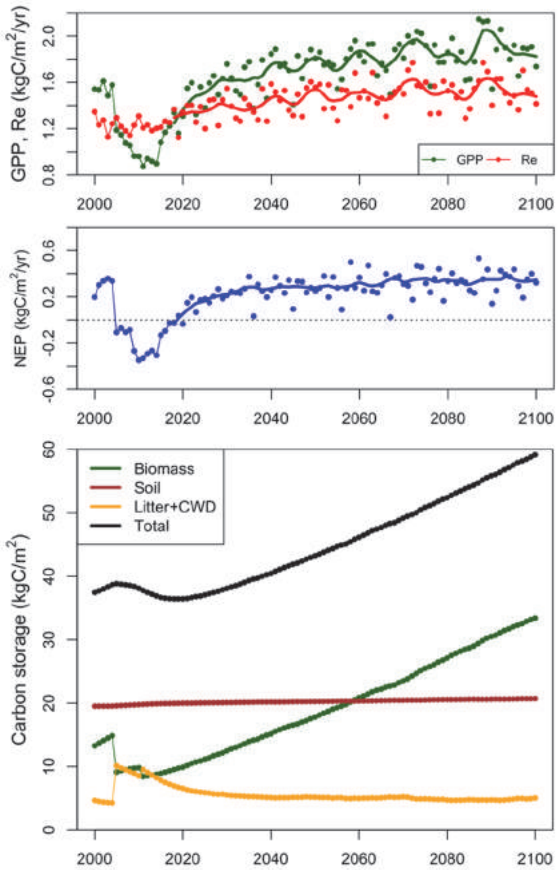

Fig. 4 Carbon flux and budget under a decline mortality and RCP 4.5 pathway.

P2-M5

Applicability of daily evapotranspiration models of spring maize based on eddy covariance

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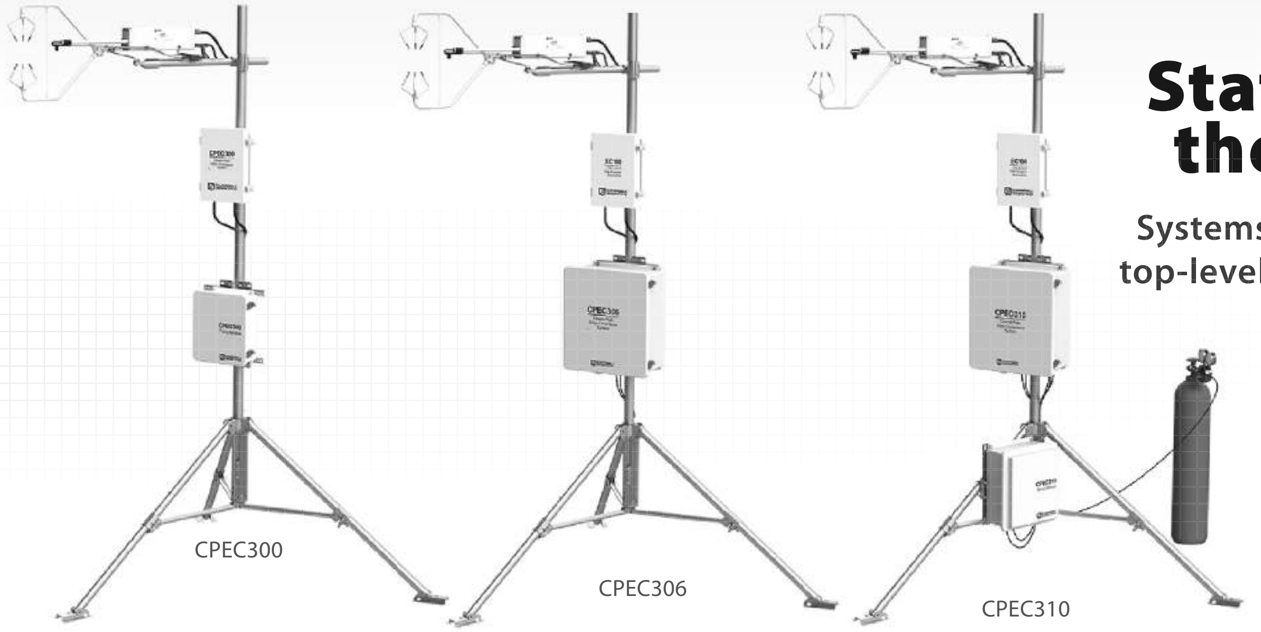
2. Chinese Academy of Meteorological Sciences, Beijing 100081, China

The evapotranspiration is a basic parameter for the vegetation evapotranspiration calculation, the regional water balance analysis, and the water resources management. The evapotranspiration models have different adaptability for different regions or crops. In order to accurately estimate the evapotranspiration of spring maize at different growth stages, the applicability of six daily evapotranspiration models (combined method, FAO 56-Penman-Monteith; temperature-based methods, Hargreaves-Samani, Blaney-Criddle; radiation-based methods, Makkink, Jensen-Haise and Priestley-Taylor) were evaluated in spring maize farmland ecosystem. This study was conducted based on latent flux data from eddy covariance during 2007-2008 at Jinzhou Agricultural Ecosystem Research Station and by using the linear weighted sum method and three statistical indicators: correlation coefficient, mean bias error and root mean square error. The results showed that: 1) The average daily variation of evapotranspiration at different growth stages was expressed as a single peak curve and the maximum of daily evapotranspiration appeared at initial stage of flowering; 2) Different canopy density differences of spring maize at different growth stages displayed effect on evapotranspiration. The general evaluation results indicated that the radiation-based models performed better than combined and temperature-based methods excluding Priestley-Taylor model; 3) The calibrated Blaney-Criddle model in seedling stage, the original Jensen-Haise model in heading stage and the calibrated Makkink model in flowering stage accurately evaluated the evapotranspiration of spring maize. In conclusion, the results provide references for estimating daily spring maize evapotranspiration at different growth stages in Northeast, China.

Business Advertisement

CPEC300, CPEC306, and CPEC310

Closed-Path Eddy-Covariance Flux Systems



State of the Art

Systems ideal for top-level research

Overview

The CPEC300-series systems are turn-key, closed-path eddy-covariance (EC) flux systems for long-term monitoring of atmosphere-biosphere exchanges of carbon dioxide, water vapor, heat, and momentum. Three models are offered that support different applications:

- CPEC300—A basic, entry-level, closed-path eddy-covariance flux system that is a good solution for sites with fewer sensors and a short tower
- CPEC306—A mid-level, expandable, closed-path eddy-covariance system that is a good solution for sites with many sensors and either a short or tall tower
- CPEC310—A high-end, expandable, closed-path eddy-covariance system that is a good solution for sites with many sensors and either a short or tall tower, and that will use automatic zero and span

Each system typically includes an EC155 closed-path gas analyzer, CSAT3A sonic anemometer (ordered as an option), CR6 datalogger (ordered as an option), sample pump, and enclosures that house the electronics. The CPEC310 also has a valve module that provides automatic zero and span, and an optional scrub module that provides a convenient source of zero gas. Often the CDM-A116 16-channel analog input module is ordered with a CPEC306 or CPEC310 to connect additional energy-balance and meteorological sensors. The CDM-A116 fits inside the system enclosure.

The EC155 gas analyzer's intake design and small sample cell volume (5.9 mL) provide excellent frequency response (4.3 Hz cutoff frequency) with low total system power (12 W). Additionally, the now-available vortex intake greatly reduces maintenance and maintains frequency response compared to traditional inline filters.

Benefits and Features

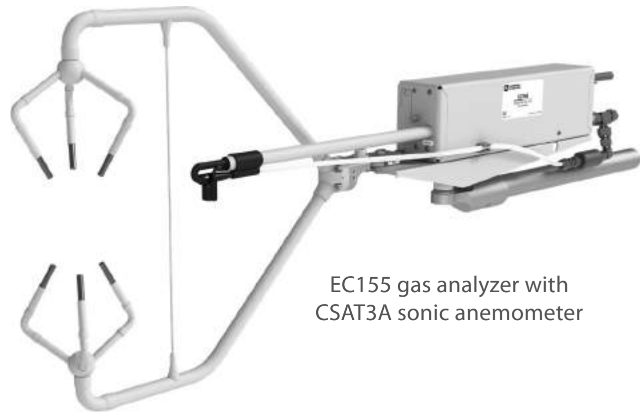
- Ease of use
  - Vortex intake greatly reduces maintenance compared to inline filters
  - EasyFlux™ datalogger program requires minimal input from station operator
  - Active system flow control; EC and zero/span flows set by datalogger program variables
  - System operates continuously during inclement weather
  - Heated sample intake prevents condensation
  - Installation requires minimal tools
- Excellent system frequency response (see graph on next page)
- Low power
- Onboard data storage available using microSD cards; maximum 8 GB or 8 months at 10 Hz measurement frequency
- Remote data collection, including direct (Ethernet, RS-232, short haul modem, landline[a]) and wireless (Wi-Fi, RF, cellular[a], satellite[b])

[a]*Collecting high frequency time series is possible, but may be cost prohibitive.*

[b]*Only online statistics can be collected using satellite.*

Science Measurements

CO_2 and H_2O are measured with an EC155 Closed-Path Gas Analyzer. Three-dimensional wind speed and sonic air temperature are measured with a CSAT3A sonic anemometer head.



EC155 gas analyzer with CSAT3A sonic anemometer

CPEC300-series System Enclosures

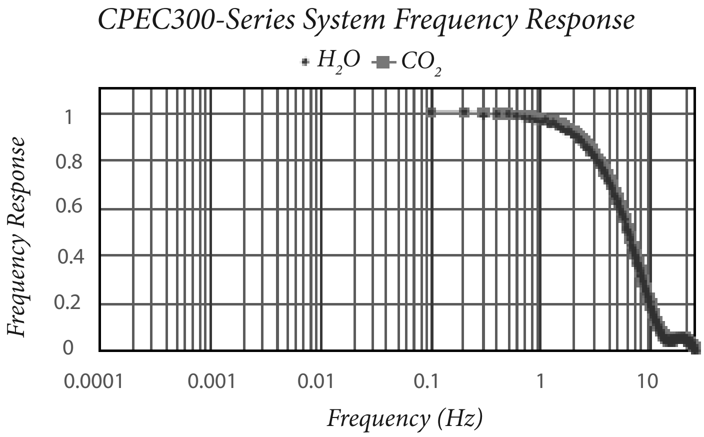
The CPEC300 series uses fewer enclosures than the previous system. The CPEC300 has only two enclosures: the EC100 enclosure of the CPEC300 that contains the CR6 datalogger, and the pump module enclosure. Both the CPEC306 and CPEC310 have two enclosures: a fiberglass enclosure that houses the CR6 datalogger, pump module, and optional CDM-A116, and the EC100 enclosure for data processing. The CPEC310 can also be equipped with a scrub module for automatic zeroing of the EC155. The CPEC300-series system enclosures can be mounted to a tripod mast, CM106B tripod leg base, tower legs, or a large-diameter pole.

CPEC300-series Pump Module

The pump module, a standard component of the CPEC300-series system, consists of a small dual-head diaphragm pump with a brushless dc motor mounted inside a fiberglass enclosure. An integral cable connects the pump module to the CPEC300 enclosure, which provides power, temperature measurement and control, pressure measurement, and pumping speed measurement and control. The CPEC306 and CPEC310 come with the pump module contained within the main fiberglass enclosure.

Valve Module

The CPEC310 comes with a three-valve module that enables the system to automatically perform zero, CO_2 span, and H_2O span measurements.



Specifications[c]

- Operating Temperature: -30° to +50°C
- Input Voltage: 10.5 to 16.0 Vdc
- Power: 12 W (typical); 35 W (maximum (at cold startup)
- View the EU Declaration of Conformity document at: www.campbellsci.com/cpec300, www.campbellsci.com/cpec306, or www.campbellsci.com/cpec310

System Enclosure

- Dimensions
  CPEC300: 34 x 25 x 13 cm (13.4 x 9.8 x 5.1 in)
  CPEC306/310: 54 x 44.5 x 29.7 cm (21.3 x 17.5 x 11.7 in)
- Weight
  CPEC300: 4.02 kg (8.85 lb)
  CPEC306: 13.72 kg (30.25 lb)
  CPEC310: 15.36 kg (33.85 lb)
  CDM-A116 Module: 0.88 kg (1.95 lb)

[c] *Refer to the EC155 and CSAT3A product brochures for closed-path gas analyzer and sonic anemometer specifications.*

Pump Module

- Cable Length for CPEC300: 3.0 m (10 ft)
- Inlet Connection for CPEC300: 3/8 inch Swagelok®
- Pressure Sensor Range: 15 to 115 kPa
- Pumping Speed: 3 to 9 LPM (automatically controlled at the set point, typically 8 LPM)
- Dimensions for CPEC300: 35.6 x 29.2 x 13.5 cm (14.0 x 11.5 x 5.3 in)
- Weight for CPEC300 without mounting bracket: 5.4 kg (11.8 lb)

CPEC310 Three-Valve Module

- Inlets: Zero, CO_2 span, and H_2O span
- Outlets: Analyzer and H_2O bypass
- Connections: 1/4 inch Swagelok®
- Flow Rate: 0.5 to 5 LPM (automatically controlled at user-entered set point)
- Dimensions: 14.0 x 12.7 x 14.0 cm (5.5 x 5.0 x 5.5 in)
- Weight: 1.5 kg (3.3 lb)

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PRODUCTS SOLD

GREENHOUSE GAS AND TRACE GAS ANALYZERS

Greenhouse Gas Analyzers (concentration only)

- G2301 — CO_2, CH_4, H_2O
- G4301 — CO_2, CH_4, H_2O (portable)
- G4302 — CH_4, C_2H_6, H_2O (portable)
- G2311-*f* — CO_2, CH_4, H_2O (10Hz)
- G2401 — CO_2, CO, CH_4, H_2O
- G2401-*m* — CO_2, CO, CH_4, H_2O (flight)
- G2308 — N_2O, CH_4, H_2O
- G2508 — N_2O, CH_4, CO_2, NH_3, H_2O
- G5310 — N_2O, CO, H_2O

Peripherals for GHG Analyzers

- A0311 — 16-port Manifold, multiple inlet system
- A0701/A0702 — Recirculation Pump for closed system measurement
- A0314 — Small Sample Introduction Module (SSIM2) for discrete samples & dilution

Trace Gas Analyzers (concentration only)

- G2103 — Ammonia (NH_3)
- G2106 — Ethylene (C_2H_4)
- G2108 — Hydrogen Chloride (HCl)
- G2114 — Hydrogen Peroxide (H_2O_2)
- G2203 — Acetylene (C_2H_2) and Methane (CH_4)
- G2204 — Hydrogen Sulfide (H_2S) and Methane (CH_4)
- G2205 — Hydrogen Fluoride (HF) and Water (H_2O)
- G2307 — Formaldehyde (CH_2O), Methane (CH_4) and Water (H_2O)

Peripherals for Trace Gas Analyzers

- A0311 — 16-port Manifold, multiple inlet system
- A0311-*s* — 16-port Manifold SilcoNert Version, multiple inlet system

ISOTOPE ANALYZERS

Carbon Isotope Analyzers

- G2131-*i* — $\delta^{13}C$ in CO_2
- G2132-*i* — $\delta^{13}C$ in CH_4
- G2201-*i* — $\delta^{13}C$ in CO_2 and CH_4
- G2121-*i* — $\delta^{13}C$ in CO_2 -> (high range for CM)
- G2210-*i* — $\delta^{13}C$ in CH_4, CH_4 and C_2H_6 concentrations

Peripherals for Carbon Isotope Analyzers

- A0311 — 16-port Manifold, multiple inlet system
- A0701/A0702 — Recirculation Pump for closed system measurement
- A0314 — Small Sample Introduction Module (SSIM2) for discrete samples & dilution
- A0201 — Combustion Module (CM) for bulk samples
- A0302 — Automate-Fx, prep device for DIC/CO_2

Nitrogen Isotope Analyzers

- G5102-*i* — Site-specific $\delta^{15}N$ in N_2O
- G5131-*i* — Site-specific $\delta^{15}N$ and $\delta^{18}O$ in N_2O

Peripherals for Nitrogen Isotope Analyzers

- A0311 — 16-port Manifold, multiple inlet system
- A0314 — Small Sample Introduction Module (SSIM2) for discrete samples & dilution

Water Isotope Analyzers

- L2130-*i* — $\delta^{18}O$, δD in H_2O
- L2140-*i* — $\delta^{18}O$, $\delta^{17}O$, δD and ^{17}O-excess in H_2O

Peripherals for Water Isotope Analyzers

- A0101 — Standard Delivery Module (SDM) for calibration of vapor measurements
- A0211/A0325 — High-Precision Vaporizor and Autosampler for high-precision isotope analysis of liquid water samples
- A0214 — Mirco-Combustion Module (MCM) for removal of organics from liquids
- A0213 — Induction Module (IM) for matrix-bound water extraction
- A0217 — Continuous Water Sampler (CWS) for continuous water isotope analysis

- G2207-*i* — $\delta^{18}O$ and concentrations of O_2

Note: Contact Picarro for information on other, third-party, front-end compatibility!

Flux Measurement with High Precision Sensors

EKO

EKO offers instruments which measure various micro-meteorological parameters and spectra-radiometers which is used for remote sensing research;

- New Pyrgeometer
- Fast response& High accuracy pyranometer
- New UV radiometer
- Handheld Spectroradiometer
- Soil heat flux

New UV radiometer
MS-10

New Pyrgeometer
MS-20

Spectroradiometer
MS-711/MS-712

Wide band
spectrometer
MS-713

Heat Flow Sensors
HF-30S/HF-10S/
MF-180/MF-180M

Small Sensor
ML-01/ML-02/ML-020P

EKO INSTRUMENTS CO., LTD. Email: info@eko.co.jp / Web: eko-asia.com

System Integrator for
Filed Measurements

Climatec.Inc

http://www.weather.co.jp

NR01

4-component NET - Radiation sensor

NR01 is a 4-component net-radiation sensor that is used for scientific-grade energy balance studies. The instrument has separate measurements of solar (Short Wave or SW) and Far Infra-Red (Long Wave or LW) radiation. Major improvements relative to comparable instruments include weight (reduced), solar offsets in the LW signal (reduced), ease of leveling (high, because levelling assembly is included).

Measured downward longwave radiation*
global solar radiation
net radiation
reflected solar radiation
upward longwave radiation*
Option albedo or solar reflectance
sky temperature*
solar duration
surface temperature*

SR20

class A (secondary standard) Pyranometer

SR20 is a pyranometer of the highest category in the ISO 9060 classification system: secondary standard. This solar radiation sensor is used where the highest measurement accuracy is required. It measures the solar radiation received by a plane surface, in W/m², from a 180 ° field of view angle. SR20 secondary standard pyranometer enables you to attain the highest measurement accuracy and excels in demanding applications. After a thorough programme of acceptance testing, SR20 was released February 2013. It offers analogue millivolt output.

Measured hemispherical solar radiation
ISO 9060:2018 classification class A (secondary standard)
IEC 61724-1:2017 compliance

CT Bldg.6F, 4-2-1, Ikebukuro, Toshima-ku, Tokyo, Japan, 171-0014
Mail: sales2@weather.co.jp
Phone: +81-3-3988-6616
Fax: +81-3-3988-6613

System Integrator for
Filed Measurements

Climatec.Inc

http://www.weather.co.jp

Measuring range 0-1500ppm(CO2)
Measurement accuracy ±10%   S.D.
Chamber flow rate 500-1200ml/min
Weight Console:4.5kg Head:2.2kg
LED 1200μmolm-2s-1
Power Over 3hours with standard lithium ion battery 6.4Ah

MIC-100

High-speed Photosynthesis Rate Measurement System

MIC-100 is a very unique system to measure photosynthesis rates at high speed by focusing measurement tools on the photosynthesis ability of plant leaves. This System is the most suitable for collecting large quantities of comparative data od many kinds of samples.

C-M1001

Handy SWC monitor with true TDR digital (SDI-12) sensor

CLI-190R-W

To prevent “aging” for LI-190R, Enclose it in the pyranometer case.

ThermoLeaf

Compact waterproof(IP67) temperature and Humidity logger

OptLeaf

Compact waterproof temperature and Humidity logger

CT Bldg.6F, 4-2-1, Ikebukuro, Toshima-ku, Tokyo, Japan, 171-0014
Mail: sales2@weather.co.jp
Phone: +81-3-3988-6616
Fax: +81-3-3988-6613

PREDE *Meteorological sensor*

Ultra sonic anemometer
GILL MaxiMet
Mini weather station
GMX series
Wind speed、direction, TenmpRh,
Baro, Rain
Compus、GPS

GILL : Wind sonic

PREDE
Solar power weather station
Data logger
Various sensor

Kipp&Zonen
Pyranometer

Pyranometer CMP3
（Kipp&Zonen）

CMP3:second class
Wave length：310～2800nm
CMP3E：second class
Wave length：310～2800nm
Sensitivity：7mV／（kW・m－2）

IR sensor CGR3 (Kipp&Zonen)

Wave length 4.5～ 40μm
sensitivity 5～7 μV/Wm²
field of view : 150°
Temp sensor：Pt100Ω

SKYE Instruments

SKP-215 ：Par sensor （400～700nm）
SKR-110 ：UV2chSensor （660、730nm HBW50nm）
SKU-420 ： UVA Sensor （315～380nm）
SKU-430 ： UVB Sensor （280～315nm）

PREDE
Shadow blade PRB-50

PREDE Pyranomete rPCM-01N

PREDE Mini series

This device is an economical sensor.
Suitable for various application control and micro-weather observation.
The calibration is all calibrated with our high-performance sensors.

	UV sensor	Par sensor	Looks sensor	Pyranometer	IR sensor
	PCU－01D	PAR－01D	PCL－01D	PCM－01N	PRI－01
Wave length	280 ～ 400nm	400 ～ 700nm	400 ～ 700nm	315 ～ 2800nm	6～14μm
Detector	Si	Si	Si	Thermo pile	Thermopile
Sensitivity	5mV / kW・m⁻²	0～3、000μMol・m⁻²/0～10mV	0 ～ 150,000Lx/0 ～ 10mV	5mV / kW・m⁻²	5 μV／W/m2
Cable length	10m	10m	10m	10m	10m
			Visibility correction		Pt100Ω

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

PREDE *Meteorological sensor*

Heat Flux Sensor PHF-02, (PREDE)

The PHF-02 is a sensor measuring the heat flux from a Wall or window.Especially. This is Epoxy resin.
The sensor calibrate it individually and the pass heat capacity of the unit aria output in mV.

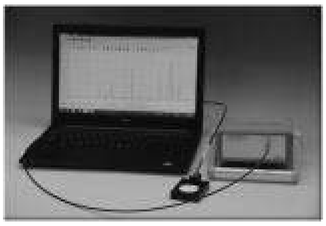
Standard calibration: <36W/m^2/mV
Standard internal resistance:2Ω
Dimention:40x5mm
Material: Epoxy resin
Cable: 5m

Ventilated precision thermometerPKFT-100

This vertical ventilation thermometer is forced circulation type ventilation tube.
Motor fan is built in at the top to force air circulation.
The material is aluminum and resin to improve weatherability, heat insulation, and reduce weight. Extremely accurate temperature measurement is possible because of the special structure of the internal shape.

PREDE Multipurpose spectral radiometer MSR-7000.

PREDE Portable spectrometer PSR-1000



This spectroradiometer is a compact spectrometer.
The light is separated by the grating method, and can be measured continuously from ultraviolet to infrared.

Model:MSR-7000
Method of incident: Optical fiber opening angle:22°
Optical system:Czerny-Turner type
Wave Length drive: Pules motor and Sign bar
Wave Length feed:1nm/about 0.1sec
Resolution: 5nm
Wave length accuracy:±1nm
Wave length aria: 280nm-2500nm
200nm-2500nm
Ditector: Photopal,Si,Pbs
Inter face:USB
OS:windows
Power:AC100V2A
Dimension:W540mmXD263mmXH272mm
Weight:15kg

PREDE
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