OzFlux – AsiaFlux Conference 2018

Ecosystems, climate & land-use change across Asia & Australasia

20-26 August 2018, Darwin, Australia

Conference proceedings

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Welcome

Welcome to the inaugural OzFlux-AsiaFlux Joint Conference 2018 (OAFlux18) in Darwin, Northern Territory, a conference that for the first time brings the Ozflux and AsiaFlux research groups together to explore "*Ecosystems, climate & land-use change across Asia & Australasia*".

The conference will showcase research investigating climate change and land use change impacts on agricultural and natural ecosystems across the Asian and Australasian region. We have brought together microclimatologists, ecosystem modellers, ecologists and social scientists from across the region to foster closer collaboration between the OzFlux and AsiaFlux networks.

The conference was inspired by the need for greater collaboration between the OzFlux network (ozflux.org.au), supported by Australia's Terrestrial Ecosystem Research Network (TERN), and the international AsiaFlux Network (asiaflux.net). OzFlux and AsiaFlux are nationally and internationally focussed ecosystem research networks that provide the Asian, Australasian and global ecosystem modelling communities with standardised observations of energy, carbon and water exchange between the atmosphere and key terrestrial ecosystems. This knowledge is critical to inform decision making and risk assessment relating to land use and climate change impacts on ecosystems.

OAFlux18 features a wide range of themes from the latest developments in instrumentation and software to spatial scaling and modelling, greenhouse gas emissions, drivers of carbon sequestration and food security. The conference has received great support from Government departments, key land management and research agencies operating across the region, as well as leading manufacturers of environmental data acquisition systems.

Delegates have come from 10 countries across Asia and Australasia ensuring the conference will meet its prime goal of developing closer ties between both natural and social scientists of the region and we extend a warm welcome to all and wish them an exciting week at OAFlux18!

Professor Jenny Davis
Dean, College of Engineering, Information Technology and Environment
Charles Darwin University

Dr Suzanne Prober
CSIRO Land and Water
Chair of OAFlux18 Organizing Steering Committee

Professor Yu Guirui
Chair of AsiaFlux
Chinese Academy of Sciences

Conference objectives

- To investigate climate change and land use change impacts on the dominant ecosystems across the Asian and Australasian region
- To bring together microclimatologists, ecosystem modellers and ecologists from the region and foster closer collaboration between the OzFlux and AsiaFlux networks
- Promote the importance of understanding ecosystem processes and future impacts to policy and decision makers
- To publish a special issue arising from the meeting

Conference themes

The conference will focus on ecosystems, climate and land use change;

- Ecosystem responses to interannual climatic and biophysical variability
- Food security – responses of agricultural ecosystems to climate extremes
- Greenhouse gas emissions from agricultural and natural ecosystems
- Linking flux observations with remote and proximal sensing and land surface models
- Ecohydrology, ecosystems and climate change
- Reactive trace gas fluxes and aerosol formation in forest ecosystems
- Eddy covariance methods – next generation instrumentation and software systems
- Integrated analysis of greenhouse gases fluxes at country to continental scales
- Knowledge transfer to the policy makers

Steering Committee

Suzanne Prober (CSIRO) (Chair)

Craig Macfarlane (CSIRO) (Secretary)

Jason Beringer (University of Western Australia)

David Campbell

James Cleverly (University of Technology Sydney)

Pippa Featherston (CDU)

John Hunt (landcare Research, NZ)

Lindsay Hutley (CDU) (OzFlux Conference Coordinator)

Kazuhito Ichii (Chiba University, Japan)

Peter Isaac (TERN)

Mirko Karan (TERN)

Hyun-Seok Kimm (Seoul National University, Korea)

Mike Liddell (James Cook University)

Yukimi Nakata (National Institute for Environmental Studies, Japan) (AsiaFlux Conference Coordinator)

Shuli Niu (Chinese Academy of Sciences, China)

Youngryel Ryu (Seoul National University, Korea)

Masahito Ueyama (Osaka Prefecture University, Japan)

Carmel Walker (CDU)

Leiming Zhang (Chinese Academy of Sciences, China)

Plenary speakers

Professor Albert Van Dijk

Australian National University, Canberra

Professor Albert Van Dijk established and leads the Centre for Water and Landscape Dynamics at the Fenner School of Environment and Society. In 2002, Prof van Dijk received his PhD in Environmental Sciences from VU University Amsterdam, The Netherlands and was subsequently joined CSIRO's Division of Land and Water from 2003 to 2012, where he won awards for his leadership role in the Murray-Darling Sustainable Yields project, possibly the most ambitious water resources study ever undertaken. Professor van Dijk led the development of the Australian Water Resources Assessment system, a model-data integration system now operational in the Bureau of Meteorology.

In 2012 he was appointed as Professor of Water Science and Management at the Fenner School of Environment & Society in the Australian National University's College of Science.

Professor Van Dijk has authored more than 140 publications addressing the interaction between vegetation and the hydrological cycle and related processes, such as soil erosion, nutrient cycling, salinity, the surface energy balance, the carbon cycle, fire risk, biodiversity, ecological resilience, and crop growth.

He has a passion for practical research applications, including the observation and forecasting of natural hazards, water resources, environmental condition and agricultural production. The theory and technology involved are drawn from environmental science and management, satellite remote sensing, IT, statistics and simulation modelling.

Professor Van Dijk was inaugural chair and is currently co-chair of the Australian Energy and Water Exchange Initiative (OzEWEX).

Professor Andrew Campbell

Australian Centre for International Agricultural Research

Professor Andrew Campbell has played influential roles in sustainable agriculture and natural resource management in Australia for 30 years. He is the Chief Executive Officer of the Australian Centre for International Agricultural Research (ACIAR). From 2000-2006 he was the Executive Director of Land &

Water Australia, a rural research and development corporation focussed on innovation and sustainability in Australia's agricultural production systems. Professor Campbell was the inaugural Director of the Research Institute for the Environment and Livelihoods (RIEL) at Charles Darwin University. He has held senior policy roles in land, water and biodiversity management as a senior executive in the Australian Government environment portfolio he was instrumental in the development of Landcare, working with the National Farmers' Federation and the Australian Conservation Foundation to develop the proposal that catalysed the Decade of Landcare. He was Australia's first National Landcare Facilitator from 1989-92, and he pioneered the concept of Whole Farm Planning as Manager of the privately-funded Potter Farmland Plan initiative in western Victoria in the 1980s.

Professor Campbell is a Fellow of the Australian Institute of Company Directors (AICD) and chairs the board of the Terrestrial Ecosystem Research Network (TERN), an Australian national research infrastructure facility hosted by the University of Queensland. He is a Visiting Fellow at the Australian National University's Fenner School, a Commissioner with the IUCN's World Commission on Protected Areas, a member of the Science Advisory Panel of Landcare Research New Zealand, and Patron of Landcare in Victoria. Andrew Campbell trained in forestry at Creswick and the University of Melbourne and rural sociology at Wageningen University in The Netherlands. He has written more than 100 publications and blogs on landcare, sustainability (food, water, energy and climate) and knowledge management.

Professor Hiroyuki Muraoka

River Basin Research Center, Gifu University, Japan

Professor Hiroyuki Muraoka was awarded a PhD in Biological Sciences from the University of Tsukuba in 1999. He is a Senior Professor at the River Basin Research Center, Gifu University, Japan.

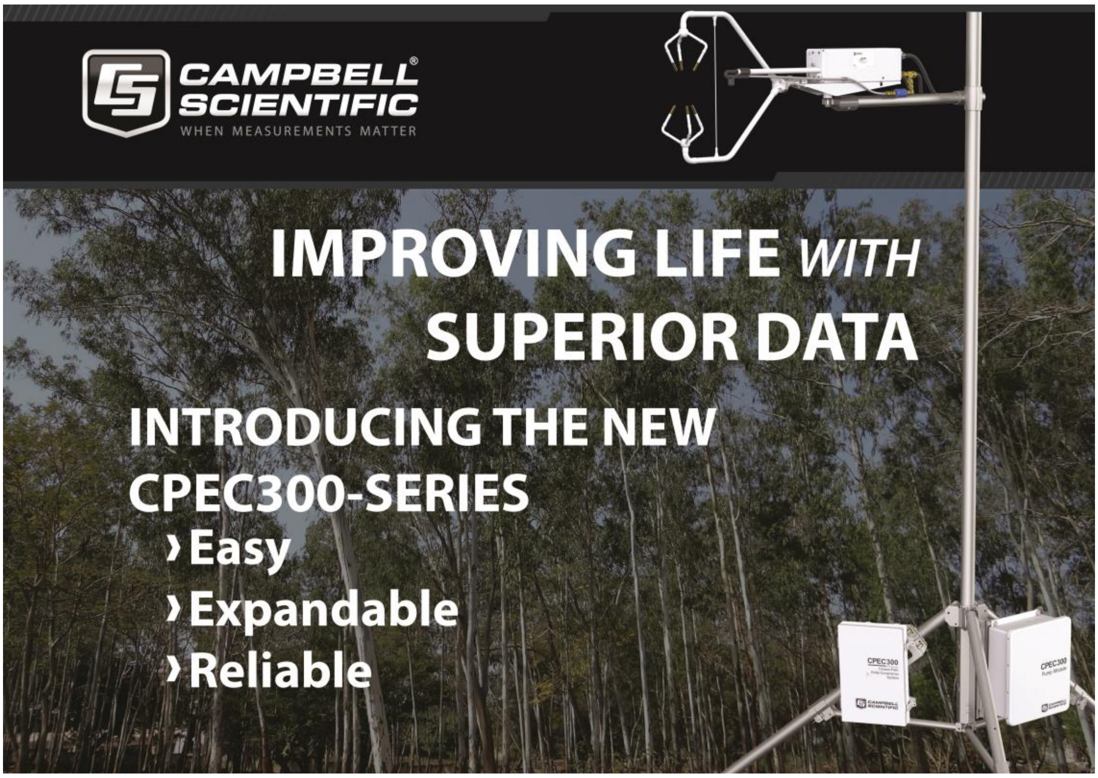
Professor Muraoka has a wide range of research interests, including the physiological ecology of terrestrial plants, particularly leaf photosynthetic response to changing environments and plant phenology. Linking plant physiological ecology, micrometeorology, remote sensing and simulation model for cross-scale analysis of carbon cycle in forest ecosystems is a key focus. Professor Muraoka also teaches in plant physiological ecology, ecosystem ecology and environmental science.

Since 2006, Professor Muraoka has been contributing to Japan Long-Term Ecological Research network (JaLTER) and is the current Chair of the East-Asia Pacific Regional Group of the International Long Term Ecological Research Network (ILTER-EAP). He is also involved in Asia-Oceania GEOSS Initiative for Asia-Pacific Biodiversity Observation Network (AP BON) and GEO Carbon and GHG Initiative (GEO-C) which are the activities contributing to the Group on Earth Observations (GEO).

Host and Supporting Agencies

The OAFlux18 Organising Committee would like to thank the generous support from international research agencies and sponsors as without this support it would not be possible to host this conference.

Silver Sponsors



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Plenary Speakers and Student Prizes

TERN OzFlux Land-Atmosphere Observatory

National Institute for Environmental Studies, Japan

NCAM National Center for Agro Meteorology


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Venues and maps

The conference will be held in Darwin, NT and hosted by CDU's Research Institute of Environment and Livelihoods (RIEL).

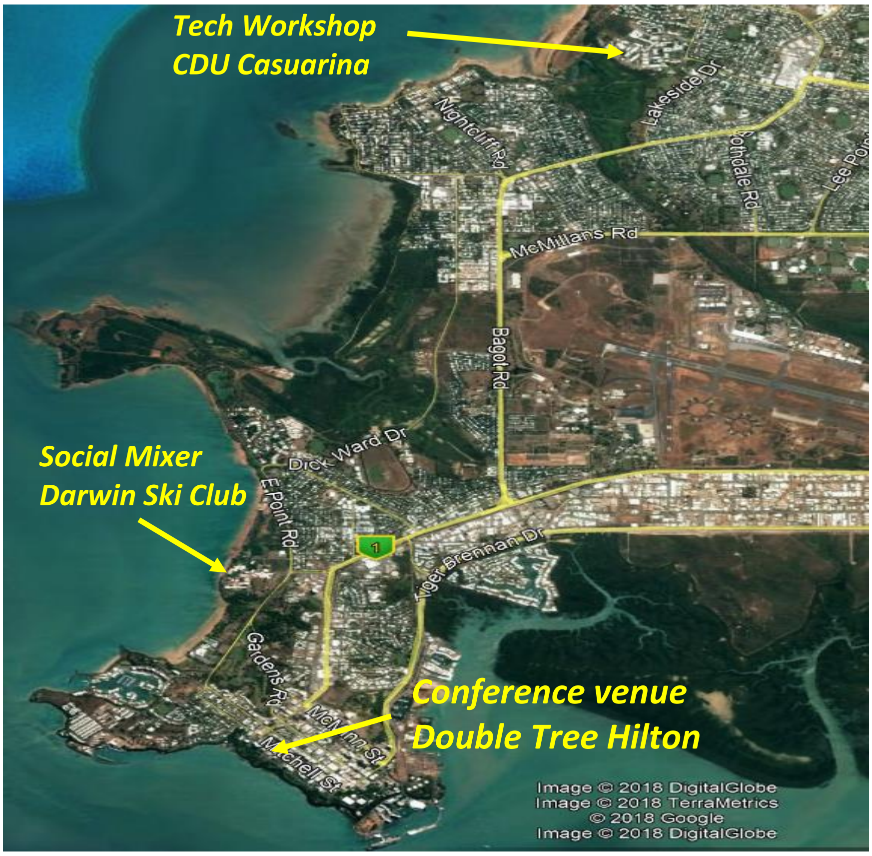
The conference and will include a three-day technical workshop, a three-day scientific meeting and a field day that will highlight local ecosystems and the ecosystem flux monitoring program that is part of TERN OzFlux and Australian Supersite Network's NT based sites.

The event will be held at the Charles Darwin University (CDU) Campus and the Double-Tree Hilton Hotel from **20th – 26th August 2018**:

- Technical Workshop: Monday 20th to Wednesday 22nd (CDU Campus Casuarina)
- Social Mixer: Wednesday 22nd (Darwin Water Ski Club)
- Conference: Thursday 23rd to Sat 25th (Doubletree Hilton Esplanade, Darwin City)
- Field program: Sunday the 26th August (Litchfield National Park)

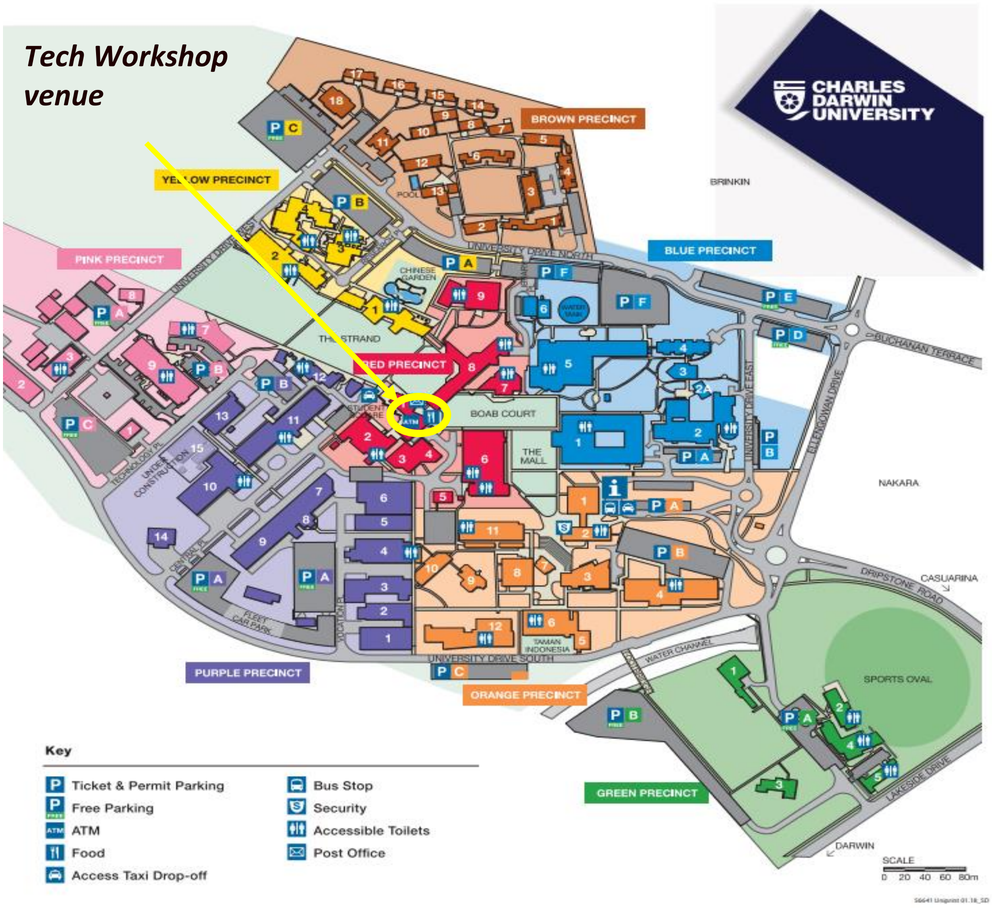
Venue maps for the Tehncical workshop and Conference are given below.

Darwin City



Technical Workshop
20-22 Aug

CDU Casuarina Campus
Casuarina 0815
Building Red 1
Level 3, Room 01

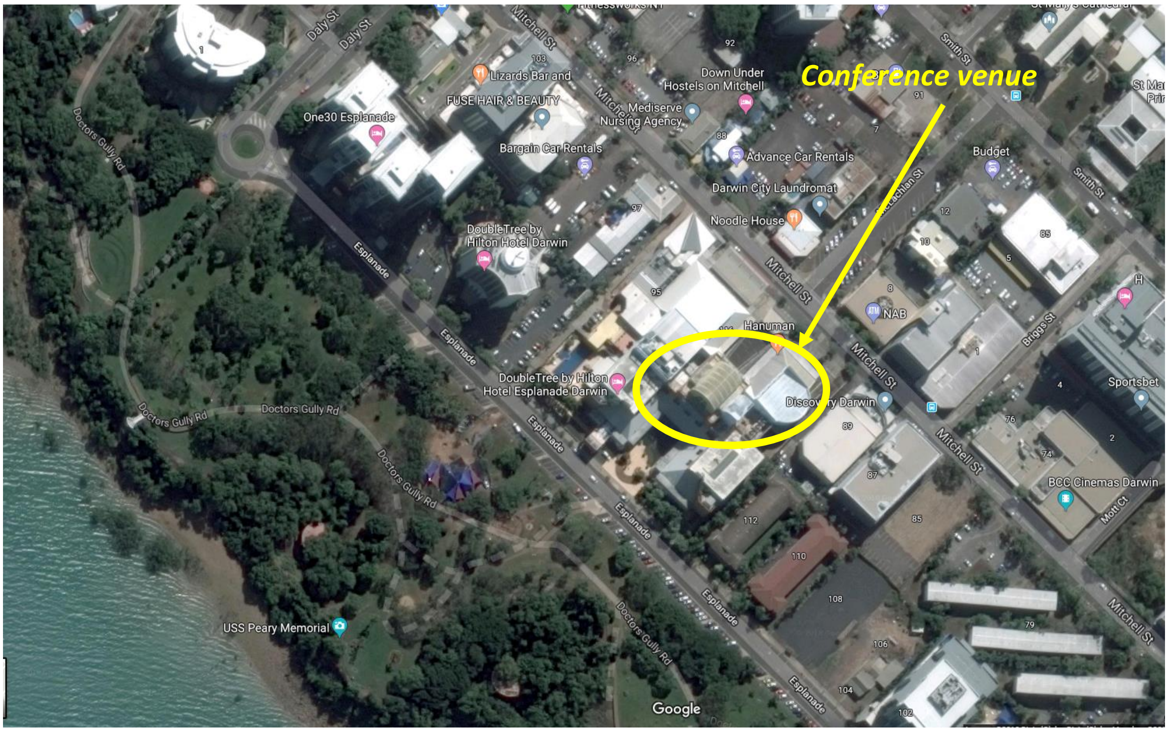


Campus map at www.cdu.edu.au/sites/default/files/CASmap12.pdf

Social Mixer
Wed 22nd 5:30 to 7:30 pm

The Darwin Ski Club
20 Conacher St, Fannie Bay

Conferece venue
23-25 Aug
DoubleTree by Hilton Hotel, Esplanade
116 The Esplanade, Darwin, TEL: +61-8-8980 0800



Please note that there are ***two*** *DoubleTree by Hilton branded hotels adjacent to each other on the Esplanade. Our venue is Hilton Hotel Esplanade Darwin, 116 Esplanade.*

Field Program - Litchfield National Park, TERN Savanna SuperSite & Waterfall Tour
Sun 26th Aug

Program

Monday 20th to Wed 23rd Aug 09:00-17:30	**Technical Workshop – Casuarina Campus, Charles Darwin University** **Building Red 1.3.1** Program at https://www.oaflux18.com/technical-workshop	
Wed 23rd Aug 17:30-19:30	**Social Mixer – Darwin Water Ski Club, Fannie Bay** https://www.darwinskiclub.com.au/	
Thursday 23rd Aug	**Day 1 OAFlux18 - Grand Ballroom, Doubletree Hilton Hotel**	**Speaker**
08:00	*Conference registration, Foyer Grand Ballroom*	
08:30	Welcome to Country	Richard Fejo (Larrakeyah Elder)
	Conference Opening	Professor Jenny Davis (Dean CDU)
	Welcome to Delegates from OzFlux and AsiaFlux	Dr Suzanne Prober (Director OzFlux)
	Housekeeping	Professor Guirui Yu (Chair AsiaFLux)
Session 1	**Process Understandings Chair: Jason Beringer**	
09:00	**Plenary Address 1** ***Let me count the ways: how OzFlux has transformed ecosystem science, and still can***	**Professor Albert van Dijk** (Australian Natural University, Australia)
09:40	S1-1: Why is the temperature optimum for canopy photosynthesis lower than that for leaf photosynthesis?	Dushan Kumarathunge*
10:00	S1-2: Abiotic decomposition and the hidden land carbon sink in central Australia	James Cleverly
10:20	**Morning tea (30 minutes)**	
Session 2	**Process Understandings Chair: Anne Grielbel**	
10:50	S2-1: Forest structure predicts its decadal carbon budget in a cool-temperate forest	Kentaro Takagi
11:10	S2-2: Influence of diffuse radiation and its timescale effects on gross primary productivity in a mid-subtropical planted coniferous forest ecosystem	Leiming Zhang
11:30	S2-3: No rain no worries? – An in-depth look into the oxidation of atmospheric methane in seasonally dry tropical soils	Philipp A. Nauer
11:50	S2-4: Feedback of soil organic carbon decomposition to artificial soil warming	Munemasa Teramoto
12:10	S2-5: Species-specific carbon and hydrological responses to three-year drought in temperate forests of Korea	Hojin Lee*
12:30	**Lunch (1 Hour)**	

Session 3	**Disturbance, Hotspot Chair: Philipp Nauer**	
13:30	S3-1: Impact of stand replacing fire on carbon and water balance of an Old Growth Mountain Ash forest	Jason Beringer
13:50	S3-2: Semi-arid woodland above ground carbon increases after fire	Wayne S Meyer
14:10	S3-3: Intra-annual variability in stem growth of temperate eucalypts in relation to climate, competition and fire	Nina Hinko-Najera
14:30	S3-4: Tidal wetland restoration Blue Carbon benefits hindered by rainfall	Grant C Edwards
14:50	S3-5: Five-year measurement of net ecosystem CO2 exchange from a fen in Zoige peatlands, Qinghai-Tibetan Plateau	Huai Chen
15:10	**Afternoon tea (40 minutes)**	
Session 4	**Solar-induced chlorophyll fluorescence Chair: Jennifer Peters**	
15:50	S4-1: On the relationship between SIF and GPP across biomes evidenced from ground and satellite measurements	Yongguang Zhang
16:10	S4-2: On-going challenges and future perspective of satellite based solar-induced chlorophyll fluorescence	Hibiki Noda
16:30	S4-3: Diurnal Changes of Chlorophyll Fluorescence Parameters and Their Relationship with Vegetation Productivity in Subtropical Coniferous Forest	Jinghua Chen*
16:50	Wrap up and house keeping	
17:00 – 19:00	**Poster Session 1**	

19:30 Conference Dinner – Grand Ballroom Hilton Hotel **Nakata Yukimi – Classical Japanese Dance**

Friday 24th Aug	Day 2 OAFlux18 - Grand Ballroom, Doubletree Hilton Hotel	Speaker
Session 5	**Application to Society Chair: Samantha Grover**	
08:30	**Plenary Address 2** ***Environmental data and agricultural intensification in Asia – let's get it right!***	**Professor Andrew Campbell** (ACIAR, Australia)
09:10	S5-1: Management of fire in tropical savannas leading to economic opportunities: A policy perspective	Kamaljiy K Sangha
09:30	S5-2: Simulating potential yields of Chinese super hybrid rice in Bangladesh, India and Myanmar with EPIC model	Wang Xiaobo*
09:50	S5-3: Food, nutritional and financial security from tree-dominated landholdings in Sri Lanka	Kamal Melvani*
10:10	S5-4: Enhancing the power of eddy covariance studies to explore grazed pastoral management practices using a split plot approach	Aaron Wall*
10:30	**Morning tea (30 minutes)**	
Session 6	**Challenges in Observation Chair: Max Lupascu**	
11:00	S6-1: Analyzing EC footprints to analysis to reconcile chamber and eddy-covariance fluxes in two contrasting boreal bogs	Pavel Alekseychik
11:20	S6-2: Assessing the surface characteristics of Australian flux tower sites and quantifying the influence of footprint variations on carbon budgets	Anne Griebel
11:40	S6-3: Continuous Field Measurement of Leaf-Level CO2 fluxes	Shih-Chieh Chang

12:00	S6-4: Validating Eddy Covariance NEP using inventory, stem growth measurements and growth models: A dry sclerophyll forest case study	Alison Bennett*
12:20	**Lunch (70 min)**	
Session 7	**Tropical Ecosystems Chair: Clint Cameron**	
13:30	S7-1: Soil Moisture as the Key Factor Controls Soil CO2 Efflux in Lowland Tropical Forest Southeast Asia	Xin Zhao
13:50	S7-2: Post-fire fluxes and sources of carbon in tropical peatlands, Brunei	Max Lupascu
14:10	S7-3: Carbon dynamics in restored secondary peat swamp forest	Meli F. Saragi-Sasmito*
14:30	S7-4: Effects of Litter Inputs on N2O Emissions from a Tropical Rainforest in Southwest China	Jinbo Gao*
14:50	S7-5: Carbon stock and sediment CO2 efflux changes following mangrove logging and regeneration in West Papua	Sigit D. Sasmito*
15:10	**Afternoon tea (20 minutes)**	
Session 8	**Agriculture, Pasture, Dryland Chair: Nina Hinko-Najera**	
15:30	S8-1: CO2 and water fluxes from grazed pastures – knowledge gained from comparisons between observations and physiologically-based modelling	Miko U.F. Kirschbaum
15:50	S8-2: Plant Transpiration and Water Balance of a Desert Ecosystem in Northwestern China	Wenzhi Zhao
16:10	S8-3: Carbon and water budgets of irrigated and non-irrigated lucerne for three years from planting	Johannes Laubach
16:30	S8-4: Nitrogen budgets for irrigated and non-irrigated lucerne and linkages to the carbon cycle	John Hunt
16:50	Wrap up and house keeping	
17:00 – 19:00	**Poster Session 2**	
	AsiaFlux Steering Committee Meeting Grand Ballroom 5-6:30 pm	
	OzFlux Steering Committee Meeting Ground Ballroom 5-6:30 pm	

Saturday 25th Aug	**Day 3 OAFlux18 - Grand Ballroom, Doubletree Hilton Hotel**	**Speaker**
Session 9	**Networking, multiple observations Chair: Craig Macfarlane**	
08:30	**Plenary Address 3** ***Networking networks toward the concerted in-situ terrestrial ecosystem observations***	Professor Hiroyuki Muraoka, (Gifu University, Japan)
09:10	S9-1: TERN and OzFlux: Infrastructure, environmental prediction and recent outputs	James Cleverly
09:30	S9-2: Coordinated in-situ and satellite flux observations over East Asia dryland	Gensuo Jia
09:50	S9-3: Ecoacoustics - linking faunal biodiversity dynamics to ecosystem fluxes	Michael Liddell
10:10	S9-4: Comparison of CO_2 flux measured over crops using flux-gradient and eddy covariance techniques	Muhamad Firdaus Sulaiman
10:30	**Morning tea (30 minutes)**	

Session 10	**Extreme Events Chair: Song Leng**	
11:00	S10-1: Incorporating non-stomatal limitation improves the ability of leaf and canopy gas exchange models to capture VPD responses	Jinyan Yang*
11:20	S10-2: Drought Resistance Traits and Thresholds of Forests across TERN Supersites	Jennifer Peters*
11:40	S10-3: Adaptive capacity of drought tolerance traits in eucalypts	Stefan Arndt
12:00	S10-4: Carbon and energy fluxes of temperate eucalypt forests in southeastern Australia during the November 2017 heatwave	Tim Wardlaw
12:20	**Lunch (90 min)**	
Session 11	**EC-network Chair: Sigit Deni Sasmito**	
13:50	S11-1: Carbon exchanges and their responses to temperature and precipitation in forest ecosystems in Yunnan, Southwest China	Yiping Zhang
14:10	S11-3: Spatial patterns and climate controls over the phenology and capacity properties of seasonal variation of carbon fluxes across terrestrial ecosystems in China	Lang Han*
14:30	S11-4: Spatial and temporal pattern of carbon exchange over ecosystems in China	Zhi Chen
14:50	S11-5: Predictability of land surface fluxes in FLUXNET 2015	Ned Haughton
15:10	**Afternoon tea (20 minutes)**	
Session 12	**Regional to Continental Scale analysis Chair: John Hunt**	
15:30	S12-1: SMAP derived soil moisture constrains greenness and photosynthesis of dryland vegetation over central Australia	Song Leng*
15:50	S12-2: Detection of positive gross primary production extremes in terrestrial ecosystems of China during 1982-2015 and analysis of climate contribution	Shaoqiang Wang
16:10	S12-3: Estimating terrestrial CO_2 fluxes across Asia based on synthesis of AsiaFlux data, remote sensing, and ecosystem modeling	Kazuhito Ichii
16:30	S12-4: Derived Optimal Linear Combination Evapotranspiration (DOLCE): a global gridded synthesis ET estimates	Sanaa Hobeichi*
16:50	Conference wrap up	
17:10 – 19:00	**Poster Session 3**	

* denotes a student presentation and eligibility for the TERN Student Prize

	Poster Presentations	Presenter
Theme 1	**Ecosystems dynamics**	
	Eddy covariance flux data quality assessment to evaluate the site in Alpine Peatland ecosystem	Dilani Gunawardhana*
	Seasonal dynamic of evapotranspiration of rubber tree (Hevea brasiliensis Müll.Arg.) plantation in different part of Thailand	Duangrat Satakhun
	Response of fine root respiration and morphology along a subalpine elevation gradient in Japan forest	Mizuki Okamoto*
	A New Way to Include Soil Water Stress in Terrestrial Ecosystem Models	Bin Chen
	Fluvial export of terrestrial carbon in a seasonally wet tropical catchment	Clement Duvert
	Plant chlorophyll fluorescence: active and passive measurements at canopy and leaf scales under different water availability	Shan Nan
	Driving Factors of Changes in Evapotranspiration from a Red Pine Ecosystem	Takumi Suzuki
	Seasonal Variations of Surface Energy Exchange and Evapotranspiration over a Shrubland of an Oasis-Desert Ecotone in Arid Regions of Northwest China	Xibin Ji
	Rainfall pulse response of carbon fluxes in a temperate grass ecosystem in the semiarid Loess Plateau	Yakun Tang
	Leaf photosynthetic capacity significantly correlates with leaf chlorophyll content in subtropical evergreen coniferous plantation	Yue Li*
	Dissolved Organic Carbon of Degraded Peat Soil with Sulphidic Substratum and Its relationship with Groundwater Level: A case study of Block C Ex-Mega Rice Project	Zafrullah Damanik
	Carbon sequestration capacity fluctuates annually with water deficit in the East Asia Semiarid Grasslands	Zhao Huichen*
	Monitoring of water stress in rice: Integration of near-surface remote sensing and eddy covariance measurements	Chompunut Chayawat
	Tools for Time- and Space-Synchronized Flux, Weather, Soil and Optical Sensor Network	George Burba
	The effects of sun-viewer geometry on sun-induced fluorescence and its relationship with gross primary production	Qian Zhang
	On Developing a Visualization Assistance Tool for the Dynamical Process Networks	Minseok Kang
	Evapotranspiration partitioning and its characteristics for winter wheat based on the concept of underlying water use efficiency in the Loess Tableland of China	Haixiang Zhou*
	Leaf uptake of monocyclic hydrocarbons by plants	Moeko Koike*
	Influence of phenological changes on CO2 uptake and the driving factors in Japanese mountain and alpine ecosystems	Reiko Ide
	CO2 balance in a northern bog located in the southern border of climatogeneous peatland zones, northern Japan	Tomotsugu Yazaki
	A comparison on data gap-filling between panel data and Artificial Neural Networks	Atbin Mahabbati*
	Using a paired tower approach and remote sensing to assess energy distribution in heterogeneous ecosystems	Daniel Metzen
Theme 2	**Environmental change and variability**	
	Response of net ecosystem production to interannual rainfall variability in an old-growth eucalypt woodland	Craig Macfarlane
	Satellite chlorophyll fluorescence captures heat stress for the winter wheat in the Indian Indo-Gangetic Plains	Lian Song*
	Eddy Covariance as a tool for monitoring tropical peatland restoration at a catchment scale	Samantha Grover

Theme 3	**Land use change**	
	EC measurements of N2O fluxes from grazed pasture identify temporal patterns and environmental controls	Aaron Wall
	Methane and Carbon Dioxide Measurements with New High-Precision Low-Power Low-Maintenancwe Closed-Path Analyzers	George Burba
	Eddy covariance and biogeochemical observations of methane dynamics in a shallow mid-latitude lake in Japan	Hiroki Iwata
	Comparison of infrared canopy temperature in a rubber plantation and tropical rain forest	Qinghai Song
Theme 4	**Emerging topics**	
	New Automated Low-Power Flux Measurements and Calculations System Accepting Multiple Anemometer Models	George Burba
	Recent Advancements in Closed-Path Eddy-Covariance Flux Systems: Faster-Response Design, Field Auto Zero/Span, and Online Full Corrections	Ning Zheng

Sun 26th Aug	**Day 4 OAFlux18 Field Program – Litchfield National Park** **TERN Savanna SuperSite & Waterfall Tour**
	Trip Hosts: Lindsay Hutley, Matthew Northwood, Jason Beringer
07:45	**Departure – DoubleTree Hilton Esplanade, 116 Esplanade, Darwin City**
10:15	Litchfield National Park – Tropical Savanna Super Site
13:15	Wangi Falls (lunch, swim, walks)
15:00	Tolmer Falls (short walk to falls)
16:00	Magnetic termite mounds – savanna herbivory
18:30	**Departure – DoubleTree Hilton Esplanade**

Oral presentations

Why is the temperature optimum for canopy photosynthesis lower than that for leaf photosynthesis?

Dushan Kumarathunge[1], Belinda Medlyn[1], John Drake[2], Mark Tjoelker[1], Jinyang Yang[1]

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[2]Forest and Natural Resources Management, College of Environmental Science and Forestry, State University of New York, 1 Forestry Drive, Syracuse, NY 13210, USA
d.kumarathunge@westernsydney.edu.au

The temperature dependence of photosynthesis (A_{net}-T response) is a key determinant of the temperature response of plant growth. However, it is currently unclear how to scale the leaf-level temperature response to whole-canopy scale. In this study, we utilised data from a whole-tree chamber experiment with *Eucalyptus tereticornis*. Measurements at this experiment demonstrate that whole-canopy photosynthesis has a temperature optimum that is >7 degrees lower than that of leaf-level photosynthesis. To explain this observation, we hypothesised that 1) there is a large contribution of non-light saturated leaves to total canopy photosynthesis and 2) photosynthetic component processes and their temperature response vary through the canopy following the gradient in incident PPFD. We tested these hypotheses using a model of canopy radiation interception and photosynthesis (MAESPA) parameterized with leaf-level physiological data and estimates of canopy leaf area. We used the model to predict whole-tree photosynthesis under several different assumptions and evaluated the results against high-resolution whole-tree photosynthetic flux measured over several seasons. Our results identified the influence of non-light saturated leaves as a key determinant of the lower temperature optimum of canopy photosynthesis. Further, we demonstrate the importance of accounting for within-canopy variation and seasonal acclimation of photosynthetic biochemistry. Overall, our study identifies key processes that need to be incorporated in vegetation models to accurately predict temperature responses of plant photosynthesis and growth.

Abiotic decomposition and the hidden land carbon sink in central Australia

James Cleverly[1], Derek Eamus[1], Rachael H. Nolan[1], Tonantzin Tarin[1], Peter Isaac[2], Craig Macfarlane[3], Lindsay B Hutley[4] and Todd M. Scanlon[5]

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Grasslands and mulga woodlands cover vast portions of the Australian interior, where their large fluctuations in carbon budget can have global implications. Abiotic decomposition as a result of photodegradation (i.e., light-mediated breakdown of lignin in leaf litter) can be a major source of carbon to the atmosphere in these ecosystems, bypassing the soil carbon cycle when net ecosystem exchange of carbon (NEE) is dominated by net abiotic exchange (NAE). In this study, we applied flux-variance similarity and correlation analysis with a global Newton's root finder to partition NEE into gross primary production (GPP), ecosystem respiration and NAE. We found that abiotic decomposition in the hummock grassland (AU-TTE) violated CO_2–H_20 similarity, despite 97% energy balance closure. This result was the consequence of a weakening of the correlation between atmospheric carbon and water densities, given measured standard deviations of these quantities. However, a range of nominal CO_2 fluxes was found to exist for which flux-gradient theory approximately applies, from which an estimate of photodegradation could be inferred. Large carbon efflux due to NAE masked the true magnitude of GPP by enhancing NEE above the difference between ecosystem (biotic) respiration and GPP. Photodegradation and photosynthesis followed similar responses to light, emphasising the strong correlation between carbon source and sink behaviour of semi-arid central Australia. Thus, carbon source strength can be enhanced across a large area of the Australian continent due to biomass accumulation during exceptionally wet periods. The contribution of abiotic decomposition to the global carbon budget is expected to increase under future climate, which will require improved understanding and parameterisation in global models and remote sensing retrievals. By estimating photodegradation *in situ* for the first time, this study provides an important step for closing the carbon budget of a drier but more variable world.

Forest structure predicts its decadal carbon budget in a cool-temperate forest

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To estimate long-term and landscape-scale forest biomass dynamics, airborne light detection and ranging (LiDAR) is expected to be an effective method. We examined the feasibility of estimating forest biomass changes using two airborne LiDAR measurements of forest heights acquired 10 yr apart (2004 and 2014) over 225 km^2 of a cool-temperate forest in northern Japan. Whole the observed area was divided into 23,502 cells, each having the size of 1 ha, and the decadal change of the mean canopy height (*Δ*MCH) was obtained for each cell using two digital surface models observed in 2004 and 2014, then the *Δ*MCH was converted into the biomass change using a linear equation obtained from the relationship between *Δ*MCHs and the biomass changes from ground surveys. Decadal net biomass change had large spatial heterogeneity ranging from +35 to - 52 MgC ha^{-1}. The average was 4.05 (± 6.46 SD) MgC ha^{-1}, where the photosynthetic biomass increase was 11.7 (±4.79) MgC ha^{-1} and the tree carbon decrease, caused by coarse woody litter or tree falling, was 8.99 (±5.43) MgC ha^{-1}. These values were comparable with those obtained from previous studies by ground surveys or tower flux observations. The decadal net biomass change decreased with the elevation owing

to the decrease in the photosynthetic biomass accumulation and increase in the mortality. Additionally, two forest structural factors (forest biomass and canopy height heterogeneity) at initial condition strongly affect the decadal biomass change, while the effect of other abiotic and biotic factors such as slope inclination and aspect, vegetation and geology were small. Net biomass increase showed a maximum value at a certain condition for each of the forest biomass and canopy height heterogeneity. This implies that these two forest structural factors can be a good index to predict its decadal carbon budget.

Influence of diffuse radiation and its timescale effects on gross primary productivity in a mid-subtropical planted coniferous forest ecosystem

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The mid-subtropical forests in East Asia monsoon zone act as an important carbon sink. Planted coniferous forests are important vegetation types in this area. However, we lack an in-depth understanding of both controlling mechanisms of environmental and biotic factors in gross primary productivity (GPP) and their timescale effects. Based on eddy covariance carbon flux data and micro-meteorological data (2003-2015) observed at a mid-subtropical planted coniferous forest in Qianyanzhou, the path analysis mothed we used to quantify standardized total effects (STE) of environmental factors on GPP and their variabilities at different timescales. We found that GPP under cloudy weather conditions was greater than under sunny weather conditions across seasons. From daily to yearly scales, PAR had the positive STE with GPP, but such STE was gradually reduced toward yearly scale; diffuse radiation or air temperature had the positive STE with GPP at daily and monthly scales, while negative STE occurred at seasonal and yearly scales. Vapor pressure deficit exhibited the negative STE with GPP at all timescales, and such STE increased gradually toward the yearly scale. Therefore, on one hand, GPP was controlled by light conditions, but on the other hand, high air temperature in summer and water availability had a significant restraining effect over GPP, and such effect increased with the timescales from day to year. Based on the simulation results by the light use efficiency (LUE) model, it indicated that modelled GPP agreed well with the measurements when the influence of the seasonal variations of LUE and diffuse radiation were incorporated into the model, especially at the yearly scale. This further indicated that diffuse radiation, together with changes in air temperature and water supply, had a significant effect on the variations of yearly GPP.

No rain no worries? – An in-depth look into the oxidation of atmospheric methane in seasonally dry tropical soils

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Uptake of methane in well-drained soils is the sole terrestrial sink for atmospheric methane. The process is mediated by methane-oxidizing bacteria (MOB) and considered to be limited mainly by methane diffusion into soils, controlled by soil moisture and air-filled pore space (AFP). In some temperate Australian ecosystems, previous studies could explain up to 90 % of methane uptake by AFP. Yet, studies in tropical Australian savannas with strong seasonality in rainfall failed to observe clear correlations of AFP or soil moisture with methane uptake. We hypothesized that water stress of MOB might be responsible for limiting methane uptake at low soil moisture, but uptake would also shift to deeper soil layers with higher soil moisture. We investigated this in a tropical savanna soil near Darwin NT with strong seasonality in rainfall, using automated flux chambers and high-resolution soil-air and soil-moisture profiles. Measurements were complemented by MOB activity tests to disentangle the effects of soil biology and soil physics, and improve our process-level understanding of atmospheric-methane uptake in seasonally dry soils.

In agreement with previous studies, methane uptake did not vary much throughout the year, despite clear differences in soil moisture between wet and dry season. Remarkably, even after periods of up to 200 d without rain, soils never dried below 0.05 $m^3\ m^{-3}$, and we did not observe water stress on MOB activity. In some profiles, uptake extended towards deeper layers down to 60 cm, while other profiles showed a stable and narrow uptake layer within the top 15-20 cm, regardless of moisture conditions. Air-filled porosity and MOB activity together could explain most of the variability in methane uptake. This was in agreement with a mechanistic model that may be applicable to a wide variety of conditions and soils.

Feedback of soil organic carbon decomposition to artificial soil warming

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Globally, soil contains around 3,000 GtC of soil organic carbon (SOC). SOC is decomposed by soil microbiota, and CO_2 is released to the atmosphere (heterotrophic respiration, R_h). Global annual R_h is estimated as 51–57 GtC, and this large CO_2 efflux increases exponentially along with temperature rise. Therefore, it is possible that global warming increases R_h, and the increased R_h further accelerates global warming (positive feedback). Asian monsoon region covers a broad area, and a wide range of vegetation and climate types. The feedback of Asian monsoon region for global warming is thought to be critical for precise prediction for future climate change. However, data to verify the long-term warming effect on R_h in Asian monsoon forest is totally limited.

To examine the long-term feedback of SOC decomposition to global warming in Asian monsoon forest region, we set multi-channel automated chamber and artificial warming system in a warm-temperate evergreen broad-leaved forest in Higashi Hiroshima, western Japan, in September 2007. To measure R_h, we prepared 10 root-trenched plots, and 5 of them were artificially warmed by +2.5ºC by infrared heaters which was set 1.6 m above the soil surface.

Remarkable exponential relationship between soil temperature and soil CO_2 efflux was confirmed each year in each treatment. However, significant and strong relationship between soil moisture and soil CO_2 efflux was also observed during summer period from July to September. No decreasing trend of stimulatory warming effect on R_h was confirmed over the 10 years of observation. The annual increased ratio of R_h by 1°C of soil temperature rise (annual warming effect) ranged from 4.2 to 13.5%. There was a marginally significant relationship between summer precipitation and annual warming effect. This study suggested the importance of moist environment in Asian monsoon region for the sustained stimulatory soil warming effect on SOC decomposition.

Species-specific carbon and hydrological responses to three-year drought in temperate forests of Korea

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In the future, longer and severer drought events are expected as climate change progresses, and forests ecosystems, which play a major role in global hydrological and carbon cycle, could be in turn affected by drought-legacy effects. Here, we compared the responses of nearby two different temperate forest types, natural mixed broadleaved forests (TBK) where *Quercus* species are dominant and Korean pine forests (TCK) to three-year drought, which continued from 2014 to June, 2017. Tree-level sap flux data and stand-level eddy covariance data were collected in the middle region of Republic of Korea from 2015 to 2017. We found that the transpiration amount in TCK continuously decreased from 352 mm yr^{-1} (2015) to 198 mm yr^{-1} (2017) as drought progressed, that in TBK, however, increased to 245 mm yr^{-1} in 2017, which was larger than 173 mm yr^{-1} (2015) and 143 mm yr^{-1} (2016). On the contrary, evapotranspiration was relatively constant in both sites having 460.7, 422.8 and 468.3 mm yr^{-1} in TCK and 474.8, 478.8 and 424.3 mm yr^{-1} in TDK from 2015 to 2017. In terms of carbon exchange, TCK showed ~28% decrease of net ecosystem exchange (NEE) in 2017 (463 g C m^{-2} y^{-1}) compare to previous years (609 g C m^{-2} y^{-1} in 2015; 683 g C m^{-2} y^{-1} in 2016). In contrast, TBK maintained similar level of NEE during consecutive three years (671, 735, 687 g C m^{-2} y^{-1}). These differences were mainly attributed to the differences in ecosystem respiration (R_E). R_E in TCK increased ~50% in 2017 compared to previous two-year average (~1050 g C yr^{-1}), while there was ~29% increase in TBK. Our results highlight species-specific, conifer vs.

broadleaved, drought responses and the impact of drought-legacy effects on forests hydrological and carbon cycle, which could result in the changes in successional phase.

Impact of stand replacing fire on carbon and water balance of an Old Growth Mountain Ash forest

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The future availability of water for cities fed by forested catchments is a critical issue, particularly in light of worsening water shortage problems. Streamflows into water catchments are dependent on the inputs of water from rainfall, but also, critically, on losses through evapotranspiration from the catchment that can be impacted by fire by modifying vegetation cover and properties. Runoff from Mountain Ash (Eucalyptus regnans F.Muell.) forested catchments has been shown to decline significantly in the few decades following fire - returning to pre-fire levels in the following centuries - owing to changes in ecosystem water use with stand age in a relationship known as Kuczera's model. We quantified the pristine carbon and water balance at an Old Growth Mountain Ash site in Wallaby Creek (Au-Wal) using the eddy covariance approach for four years prior to a stand replacing fire that occurred during the catastrophic Black Saturday bushfires of Feb 2009. We then examined the recovery of the forest for five years post fire using eddy covariance and showed that forest evapotranspiration and gross primary productivity returned quickly to pre-burn levels within 5 years. We determined the impact of the fire period by estimating how the forest would have behaved had the fire not occurred using an Artificial Neural Network model of pre-burn forest behaviour as well as a novel ecohydrological model, Tethys-Chloris, that couples mechanisms drawn from the disciplines of hydrology, plant physiology, and ecology. Contrary to predictions from the Kuczera curve, we found that measurements of whole-forest evapotranspiration were relatively conserved and that there were only small changes in water balance that persisted for less than five years.

Semi-arid woodland above ground carbon increases after fire

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In southern Australia, the semi-arid, Eucalyptus species woodland commonly known as "Mallee" is an important ecosystem that continues to be extensively modified through clearing for arable crops and grazing. In these seasonally dry ecosystems, precipitation and available soil water are the most limiting resources affecting dry matter accumulation. However this ecosystem is subjected to wildfire about every 30 years. Monitoring of a Mallee

site as part of the OzFlux network began in 2010. In early 2014 the site was burnt. Measurement of carbon, water and energy fluxes have been made before and after the fire. Above ground dry matter for a 1ha site has been estimated from sample measurements and tree trunk characteristics. Above ground dry matter was ~ 11.4 t/ha pre-fire, ~10 t/ha 15 months post-fire and then ~ 16 t/ha 4 years post-fire. This pattern results from the persistence of dead, unburned trunks and the rapid regrowth from the tree lignotuber. Tree leaf area index (LAI) was estimated to be between 0.4 and 0.6 before the fire. For 2 months after the fire, LAI was essentially zero. Prolific stem regrowth from the lignotuber began thereafter and was estimated at 0.69,15 months later and 0.9, 46 months later. Water use measured with the OzFlux eddy covariance system reflected both the seasonal variability but also the changing form of the leaf area distribution as trees changed from mature spreading canopies to regenerating compact shrub form. Our observations have followed the demise and regeneration of a semi-arid ecosystem that is highly evolved to survive the major disturbances of fire and drought and illustrates the conservative nature of carbon turnover in this environment.

Intra-annual variability in stem growth of temperate eucalypts in relation to climate, competition and fire

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Forests growth is considered to be an important carbon sink. Temperate eucalypt forests in south-eastern Australia have the potential of high carbon sequestration rates but understanding is limited on their response to climate change and thus implications on carbon stocks, species distribution and forest management practices. Stems are the predominant carbon pool in temperate eucalypt forests and hence, quantifying climate-stem growth relationships is paramount to better understand the impact of climate change on the carbon sink strength of these forests. However, various other factors related to forest stand structure and species composition such as tree-to-tree competition and fire strongly influence stem growth and tree responses to climate change.

We quantified intra-annual climate-stem growth relationships by monitoring monthly stem growth and climate data for nearly four years, and assessed inter-tree competition on individual trees across three different fire regimes (long-unburnt, prescribed fire and post-wildfire) in a temperate mixed-species eucalypt forest (AU-Wombat).

Stem growth significantly differed between species across all seasons and showed two peak growth periods in spring and autumn, but a strong decrease during summer for some species. Temperature was the main climatic driver for intra-annual stem growth showing a bell-shaped response curve with maximum growth rates between 15 and 17ºC. Autumn rainfall influenced growth during same autumn and following spring periods while summer growth was influenced by the combined rainfall from preceding months. Negative effects of competition on climate-growth relationships were species-specific, correlated with crown classifications

and varied with season, being significant for species and in seasons with higher growth rates. Fire regime had no overall influence on stem growth except for *E. rubida* which showed significant increased growth rates under prescribed fire regime.
This study highlights the strong species-dependent responses to competition and intra-annual variability in climatic drivers of stem growth.

Tidal wetland restoration Blue Carbon benefits hindered by rainfall

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One third of global methane emissions occur in freshwater wetlands. Restoring tidal exchange to impounded wetlands on coastal floodplains worldwide has been proposed as an opportunity for avoided methane emissions and net cooling. We monitored an impounded wetland's greenhouse gas flux (GHG; CO_2 and CH_4) prior and post tidal reinstatement. After the microbial community transitioned to reflect stronger tidal influence, emissions had a reduced global warming potential (GWP) of 296 g m^{-2} yr^{-1} of CO_2 equivalents over 100 years. With the removal of a succession of high to extreme rainfall events the reduced GWP was elevated to 528 g m^{-2} yr^{-1}. However, this was achieved through a reduction in CO_2 emissions, as prior tidal reinstatement CH_4 emissions were negative (-0.07 g C m^{-2} yr^{-1}). The result highlights the need to consider a wetland's initial biogeochemistry and future rainfall trends when assessing the efficacy of tidal reinstatement for emission control.

Five-year measurement of net ecosystem CO_2 exchange from a fen in Zoige peatlands, Qinghai-Tibetan Plateau

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Little is known about the relationship between carbon sequestration and environment for some alpine peatland ecosystems with a continuous observation for years, especially on remote areas like the Qinghai-Tibetan Plateau. In this study, net ecosystem CO_2 exchange (NEE) flux was measured over a fen in Zoige peatlands, Qinghai-Tibetan Plateau, with using the eddy covariance technique. Flux results showed that diurnal CO_2 absorbed peak occurred between12:00 and 14:00, emissions peak occurred between 21:00 and 22:00 in growing season. In non-growing season, most CO_2 diurnal emissions peak occurred between 20:00 and

21:00. Carbon uptake was mainly attributed from June and July in growing season every year, and the maximum daily CO_2 uptake of -8.4 g C m^{-2} d^{-1} was measured in mid-June of 2016. Soil temperature was a leading factor of ecosystem respiration (ER), but fitting functions were different in different period. Rainfall has an important effect on NEE seasonal variability whether the amount or the rain events time. Analysis of CO_2 fluxes in five years showed Zoige peatland was a net CO_2 sink of -186.9, -133.2, -215.6, -283.4 and -53.4 g C m^{-2} yr^{-1} from 2013 to 2017, respectively. In 2016, changes of plant species in Riganqiao due to drought resulted in a lowest annual NEE, but this low NEE could not prove a strong C sink, because many dissolved organic carbon (DOC) would run off with increased soil temperature and deeper water table depth (WTD). Moreover, the highest annual NEE in 2017 also indicated the instability of carbon sequestration in fen peatland ecosystem, especially the dominant plants were mostly sedge. Therefore, in long-term scale, peatland NEE flux will be mainly affected by water condition, which as influenced by soil temperature and WTD.

On the relationship between SIF and GPP across biomes evidenced from ground and satellite measurements

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Photosynthesis by terrestrial vegetation is vital to the health of the planet and absorbs half of anthropogenic CO2 from the atmosphere. It is therefore critical to accurately measure photosynthesis at the spatial scale of ecosystem to global. Remote sensing of sun-induced chlorophyll fluorescence (SIF) has been shown a good indicator of vegetation photosynthesis or gross primary production (GPP) across diverse scales. Along with the breakthroughs of global retrievals of SIF from space-borne sensors, exploitation of SIF in improving the estimation of terrestrial GPP became a very relevant and active field. However, the relationship between SIF and GPP is still not clear across different biomes. In this presentation, we present a synthesis of field continuous measurements of SIF across biomes which is used to unravel the GPP-SIF relationships across different biomes together with improved SIF retrievals from OCO-2. We find that the slopes of raw SIF with respect to GPP are significant different among biomes, which is mainly due to the canopy structure effect. After accounting for the escape effects from canopy structure, however, a more consistent GPP model from the adjusted SIF is found across C3 biomes, but a separate model for C4 plants is still needed. This results are supported by process-based model simulations. With the new GPP models from adjusted SIF with the corresponding BRF for C3 and C4 plants, a fully observation-based and independent global GPP estimates (129.81±1.24 PgC/year) is derived for the period of 2015-2017 from OCO-2 SIF retrievals, which falls within the range of current terrestrial biosphere models and up-scaled flux tower estimates. Our findings provide a new independent constraint on global photosynthesis as well as global carbon cycle projections.

On-going challenges and future perspective of satellite based solar-induced chlorophyll fluorescence

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Satellite remote sensing is powerful tool to obtain temporal and spatial variations in vegetation structure and biochemical component of leaves in the canopy on form local to global scales. These data can be used to model the potential GPP (gross primary production) of the ecosystem and help us to scale up the knowledge acquired from the flux measurement on site scale. However, since photosynthesis is biochemical processes, which is highly sensitive to environmental condition, there are still uncertainty in the estimation. Recent advent of SIF (solar-induced chlorophyll fluorescence) remote sensing from space would enable us to observe plant status and estimate GPP more accurately. The chlorophyll fluorescence is a radiation in red and near-infrared region emitted by chlorophylls during return from excited to non-exited status. Although the signal is so weak to detect under solar condition, the spectrometer with high spectral resolution enable us to retrieve SIF by in-filling Fraunhofer lines due to SIF signal. The first SIF measurement from space on the global scale was made with TANSO-FTS onboard GOSAT, Japanese satellite, designed to measure atmospheric CO_2 and CH_4 concentrations (Joiner et al., 2011; Frankenberg et al., 2011). Since SIF is emitted in the process of photosynthesis, SIF has been utilized for observation of plant stress status and proxy of GPP (e.g., Lee et al., 2013; Parazoo et al., 2014). In recent years, more detailed models based on the underling mechanism has been developed.
Although SIF was a by-product of primary mission of GOSAT, GOSAT-2, which will be launch in 2018 fiscal year, will provide SIF as one of the products. We will introduce our on-going challenges and discuss the future perspective about studies using SIF in GOSAT and GOSAT-2 projects.

Diurnal Changes of Chlorophyll Fluorescence Parameters and Their Relationship with Vegetation Productivity in Subtropical Coniferous Forest

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Chlorophyll fluorescence has become a very powerful technique to estimate photosynthesis capacity of different plants in a rapid and non-invasive way. In this study, we characterized the diurnal changes of fluorescence parameters (photochemical efficiency of PSII, Φ_{PSII} and non-photochemical quenching, NPQ) and quantified the influence of three environmental factors of photosynthetically active radiation (PAR), leaf temperature (T_{leaf}) and relative humidity (RH)

using Boosted Regression Trees (BRT) and Pearson correlation analysis. Besides, the relationships between the fluorescence parameters and vegetation productivity (gross primary productivity, GPP) were explored. We conducted in situ chlorophyll fluorescence measurements on Slash Pine (*Pinus elliottii Engelm.*) and Masson Pine (*Pinus massoniana Lamb.*) in Qianyanzhou (QYZ) subtropical coniferous forest, Jiangxi province, China during 2016. Our results showed that Φ_{PSII} decreased to a minimum in midday and then subsequently progressively rose, while NPQ was highest at midday, significantly contrary to Φ_{PSII} (Slash Pine: $R = -0.962$, $p < 0.001$; Masson Pine: $R = -0.863$, $p < 0.001$). Among the three environmental factors, PAR played the strongest role in determining the diurnal changes of Φ_{PSII} (84% in Slash Pine and 51.8% in Masson Pine). Φ_{PSII} was negatively related to PAR (Slash Pine: $R = -0.934$, $p < 0.001$; Masson Pine: $R = -0.81$, $p < 0.001$). PAR also had an important influence on NPQ in Slash Pine (78%). But NPQ in Masson Pine was mainly affected by T_{leaf} (60.2%). In addition, we obtained the synchronous GPP from the eddy covariance flux observation in QYZ and found that GPP had a significantly negative correlation with Φ_{PSII} ($R = -0.781$, $p<0.001$), but positive correlation with NPQ ($R = 0.788$, $p<0.001$).

Management of fire in tropical savannas leading to economic opportunities: A policy perspective

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Australia tropical savannas cover approximately 25% (1.9m km^2) highly fire-prone area of a fiery continent, representing one of the pristine ecosystems across the globe. But, these systems experience very extensive wildfires spreading across vast areas almost every year. Recent advances in fire-related research, government policies to abate Greenhouse gas (GHG) emissions, and establishment of financial incentivised mechanisms have brought significant improvements as to how fire is currently managed within the Australian savannas. Integrating traditional knowledge of prescribed burning practised by the local Aboriginal people over the millennia coupled with scientific advances in fire mapping and development of GHG emissions measuring online modelling tools have led to a booming carbon economy in the region. Apart from delivering ecological benefits from managing fire such as mitigating climate change, protecting biodiversity and water resources, the current approach offers many socio-economic benefits to the remote Indigenous communities where little economic opportunities exist. This paper will describe savanna fire management practices, related policies and financial mechanisms, especially Payments for Ecosystem Services (PES) for abating GHG emissions and provisioning a broad range of ecosystem services, and the associated socio-economic benefits to the local Indigenous communities in the region. Importantly, it offers some alternatives on managing wild forest fires in neighbouring eastern Indonesia and other states across South East Asia where wild forest fires are a major problem not only threating to biodiversity or climate change but seriously impacting on people's livelihoods and health.

Simulating potential yields of Chinese super hybrid rice in Bangladesh, India and Myanmar with EPIC model

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In this study, information is collected on the weather, soils, field management and agricultural statistics in the Bangladesh, India and Myanmar (BIM) region. Crop growth parameters within the EPIC (Environmental Policy Integrated Climate) model are calibrated using cultivar data and regional experimental records of indica hybrid rice Fyou498 and Fengliangyou4 in China. Potential yields of rice are then simulated in the BIM region from 1996 to 2005. The effects of local irrigation and fertilization levels on super hybrid rice yield are examined. The potential yields of Chinese hybrid rice at local irrigation and fertilization levels in 2000 and at full irrigation and rational fertilization levels are found to be 10.22 t/ha and 11.33 t/ha, respectively. The potential for increasing monsoon rice production in the study area is 227.71 million tonnes. The eastern Indo-Gangetic Plain in India, the southeast coast of India Peninsula and the Ayeyarwady Delta in Myanmar have the largest potentials for monsoon rice production. The northeastern and southwestern areas of the Deccan Plateau and the northwestern region of the Indo-Gangetic Plain need to improve irrigation equipment to meet the water-use requirements of high-yield rice. The central and southern plains in Myanmar and northeastern India need greater access to nitrogen fertilization for high-yield rice.

Food, nutritional and financial security from tree-dominated landholdings in Sri Lanka

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Food and nutritional security are serious issues in Sri Lanka where assessments mainly focus on per capita availability of staple foods and individual crop yields. Alternately, tree-dominated landholdings can ensure continuous access to and availability of nutritious food through time and lend stability to farmers' livelihoods. To test this hypothesis, the food, nutritional and financial security afforded by tree-dominated landholdings were assessed across wet and dry seasons of the reference year and 100 years. Floristic inventories were undertaken in 85 landholdings across the Intermediate zone and crops harvested in the reference year classified into Very Short-(vegetable, leafy vegetable, cereal and pulse), Short-(root), Long- (fruit, nut and fuelwood trees) and Very Long-term (timber trees) categories based on time from investment to first return. Household income and expenditure surveys

recorded crops consumed and sold. Crop: utilities, nutrient values and phenologies were retrieved from literature. Farmers cultivated different crops for food, fuelwood, timber and income and the majority were from the Long-term category. Households were nutritionally secure because 75% of crops provided food and had the full complement of macronutrients. Long- and Very Short-term crops were especially micronutrient-rich. Households were food secure because diverse crop phenologies ensured availability and access to food through wet and dry seasons of the reference year and continuously for 100 years. Financial security was assured since 50% of the value of food produced was consumed and household labour contributions accounted for more than half the expense. Average profit was highest in the Long-term and lowest in the Short-term crop categories. The ability to generate revenue in the present and future gave stability to households and purchasing power to buy food when cultivation failed. Combinations of Short- and Long-term crops cultivated in tree-dominated landholdings provide food, nutritional and financial security to households and warrant consideration in their assessments.

Enhancing the power of eddy covariance studies to explore grazed pastoral management practices using a split plot approach

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Increasing soil C through sequestration of CO2 by manipulation of management practices has been identified as a potential method to reduce the impact of the dairy industry on New Zealand's GHG emissions. Quantifying the effects of management practices over short time periods requires the use of the net ecosystem carbon balance (NECB) method. However, this method often lacks replication, and requires a control which can suffer from spatial or temporal variability. Additionally, the footprint of eddy covariance (EC) sites may extend over multiple paddocks with each having small differences in management. One approach to increase the power of the NECB methodology is to use split plots where fluxes from adjacent treatments are measured by a single EC system depending on wind direction. We tested the viability of a split plot approach by comparing the annual CO2 exchange (NEP) of two individual adjacent paddocks (P31 and P32) with the NEP calculated for the combined area of the two paddocks (P31_32). All flux measurements were made from a single EC system.
Data availability was 50% for P31_32, reducing to 26% for P31 and 16% for P31. Gapfilling (artificial neural network) performance was better for the individual paddocks than P31_32 despite the reduced data availability. In some years, there was a significant difference in NEP between P31 and P32, however, the 4-year average annual totals were similar and not significantly different from each other. In all years, a recombined NEP (calculated as the sum of each paddock's NEP multiplied by the flux proportion originating from that paddock) was similar to that calculated for P31_32. Performing the same procedure for NECB yielded similar results. We concluded that applying a split plot approach to NECB studies is a viable method to test the effects of management practises on changes in soil C in grazed pasture systems.

Analyzing EC footprints to reconcile chamber and eddy-covariance fluxes in two contrasting boreal bogs

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The boreal peatland ecosystems remain underrepresented in Earth System models, despite covering over $3*10^6$ km^2 in Asia. A large fraction of these is comprised of bogs – rain-fed mires with developed microtopography, usually afforested to some extent. They present a challenge for the analysis and interpretation of eddy-covariance (EC) measurements due to the multiplicity of vegetation communities and high inhomogeneity of surface roughness. In such a site, one cannot be certain that the EC data continuously represent the ecosystem-scale exchange, as is usually claimed.

The EC measurements of CO_2, CH_4 and energy fluxes and extensive chamber measurements were conducted at two contrasting boreal bogs, Siikaneva-2, Finland (61.8˚N, 24.2˚E) and Mukhrino, Russia (60.9˚N, 68.7˚E). Mukhrino has a more developed microtopography of ridges and hummocks, denser tree cover and greater spring inundation than Siikaneva-2. The EC footprints were simulated using the Kormann & Meixner and Kljun models and used to upscale the chamber fluxes. Generally, the upscaled chamber fluxes closely agreed with the EC fluxes. Importantly, however, it appears that the day- and nighttime footprints differ systematically, making the statistical model for respiration (based on nighttime data) potentially unrepresentative of the daytime exchange. Besides, a wide variation in the composition of the source area was also found on the seasonal scale. The corresponding relative differences between day/night and spring/summer upscaled chamber fluxes reach 25%. The large size of microforms in Mukhrino means the EC footprint is frequently dominated by a single ridge of hollow, which enhances the deviation of measured EC flux from the exchange on the ecosystem scale. Finally, the diurnal and seasonal EC source area variations are augmented by the Kljun model as it yields shorter footprints than Kormann & Meixner.

Assessing the surface characteristics of Australian flux tower sites and quantifying the influence of footprint variations on carbon budgets

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An underlying assumption of the eddy covariance methodology requires homogeneous surface characteristics within the footprint of the flux tower, which albeit being difficult to fulfil is commonly assumed without explicit validation. We used Landsat data to examine the spatial and temporal variation of surface characteristics and to assess surface homogeneity within a central flux footprint of all Australian sites in the FluxNet2015 data set. We propose a new classification approach for surface homogeneity of flux tower sites that is based on the within footprint variability of the enhanced vegetation index (EVI), and demonstrate that surface homogeneity varies across Australian flux sites and among sites within biomes. Flux sites located in grasslands and Savannas tended to have rather homogeneous surface characteristics opposed to the flux sites located in a wetland and plantation. Evergreen broadleaf forests were characterized by moderate homogeneity with a relatively large variability between sites. Adjusting for standardized wind patterns (Griebel et al. 2016) allowed us to quantify the influence of footprint variation on mean annual carbon sequestration rates at each site. This highlighted a larger influence of surface properties on annual carbon budgets at more productive sites (evergreen broadleaf forests and Savannas) compared to less-productive and near-neutral sites. Our analysis demonstrated that footprint variations at non-homogeneous sites strongly affected site-specific carbon budgets. Consequently, site-specific surface heterogeneity needs to be accounted for to more accurately attribute changes in carbon budgets to changes in the ecophysiological drivers. Further, since flux tower-based estimates of ecosystem processes are increasingly used in regional and global modelling and remote sensing applications, we need to assess the spatial representativeness of the flux tower footprint and correct for location bias if we truly want to bridge between disciplines.

Continuous Field Measurement of Leaf-Level CO_2 fluxes

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Gross primary productivity (GPP) and ecosystem respiration of forest ecosystems together determine the direction and quantity of terrestrial carbon exchange with the atmosphere, thus have been the targets of researches since decades. Until now, our knowledge about these two parameters comes only partly from direct measurement in the field. Even the widely adopted eddy covariance method has its fundamental limitation in resolving the daytime net ecosystem exchange into the underlying half-hourly photosynthesis and

respiration. Aiming in tackling this problem, we have developed an automated closed leaf chamber system for continuous measurement of photosynthesis and respiration in the field. Novelty of this system is in its chamber design, which adds a second mask to the typical transparent cover, such that after the measurement of the net assimilation rate, the incoming solar radiation could be intercepted and the respiration rate could be measured. The system consisting of six chambers has been operating on the canopy of a *Chamaecyparis obtusa* var. *formosana* stand at the Chi-Lan Mountain (CLM) site (24°35'N, 121°25'E) in northern Taiwan since August 2016. In each chamber, a quantum sensor and a thermometer were installed for monitoring the change of photosynthetically active radiation and air temperature within the chamber. A series of six chamber measurements takes 30 minutes, with one measurement of net assimilation and one of respiration for each chamber. Therefore, we are able to continuously measure the net photosynthesis and respiration rates in a 30-min temporal resolution. The leaf respiration shows a clear diurnal pattern with much higher daytime respiration than the nighttime respiration. The photosynthesis, calculated by summing up the net photosynthesis with the respiration, is higher than the estimation by eddy covariance method. Our results demonstrate that GPP of forest ecosystems might have been underestimated.

Validating Eddy Covariance NEP using inventory, stem growth measurements and growth models: A dry sclerophyll forest case study

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Estimating carbon uptake in forests is critical for balancing the global carbon budget and for estimating regional carbon sequestration. The eddy covariance method has potential to improve estimates by directly measuring carbon exchange within terrestrial ecosystems, and large datasets are becoming available through FluxNET and other local networks of eddy covariance flux towers. However, estimates of error are typically not supplied alongside eddy covariance flux data estimates of carbon exchange, and measurements have only been validated at 3% of eddy covariance sites within Fluxnet using biometric measurements. Of those sites, agreement between biometric and eddy covariance methods is rare, a concern that is especially problematic in evergreen ecosystems. Hence, we validated Net Ecosystem Productivity (NEP) measurements of an eddy covariance flux tower site at a dry sclerophyll eucalypt forest in South Eastern Australia for a three year period (2013 -2015) by applying a novel approach that combined stem growth measurements, stand inventory and growth models. We estimated that the eddy covariance method overestimated NEP by 67.1% (± 5.6% SD) across the study period, reducing estimates of NEP from 13.3 to 4.21 (± 0.71 SD) Mg C ha^{-1} yr^{-1} in 2015, 11.28 to 4.04 (± 0.58 SD) Mg C ha^{-1} yr^{-1} in 2014, and 5.27 to 1.64 (± 0.34 SD) Mg C ha^{-1} yr^{-1} in 2013. The magnitude of the error was similar between the measurement years despite large annual differences in NEP, indicating a systematic error. Our analysis highlights that validation studies are uncommon but critical to improve the utility of eddy covariance datasets and the confidence in the carbon uptake rates of the terrestrial biosphere.

Soil Moisture as the Key Factor Controls Soil CO_2 Efflux in Lowland Tropical Forests of Southeast Asia

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The influence of climate fluctuations on ecosystem process especially at tropics is increasing of great value. As one of the key ecosystem processes, soil CO_2 efflux draws on-going discussions at different scales for dealing with climate change. However, up to now, limited knowledge of soil CO_2 efflux and its components were understood at tropical forests in Southeast Asia, where is one of three main tropical forest areas all over the world. Here, we conducted a continuous measurement of soil CO_2 efflux using a multichannel automated chamber system (with sixteen chambers) in a lowland tropical forest in Peninsular Malaysia between December 2010 to July 2014. Total soil CO_2 efflux (R_s) was partitioned into heterotrophic respiration (R_h) and autotrophic respiration (R_a) by root exclusion method. We found very weak relationship between soil temperature and soil CO_2 effluxes probably due to soil temperature varied in a small range from 22.7 to 26.7 ^oC. By contrast, soil moisture strongly affected soil CO_2 efflux. R_s was higher during wet season and lower during dry season. R_a predominated R_s during wet season while R_h accounted for large proportions of R_s during dry season. Furthermore, R_a was more sensitive to soil moisture than that of R_h. Different water responses of R_h and R_a could be explained by different optimum soil moisture, which was 22.8% and 27.6% for R_h and R_a, respectively. Our results provide insight into assessing and predicting future soil carbon emission of tropical forest.

Post-fire fluxes and sources of carbon in tropical peatlands, Brunei

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Tropical peatlands hold about 15–19% of the global organic carbon (C) pool of which 77% in Southeast Asia. Nonetheless, Southeast Asian peatlands have been exploited for timber and land for agriculture leading to frequent fires in the region. Direct C-emissions through peat combustion must be quantified to examine the impact of peat fires on global and regional C-budgets, however it is also essential to evaluate oxidative decomposition of peat after fires for a complete understanding of ecosystem-scale fire impact. After a fire, ecosystems act as a C-source for months-to-years as C emissions to the atmosphere exceed photosynthesis.
Within this context, we are quantifying the magnitudes and patterns of ecosystem-atmosphere emissions of R_{eco} and CH_4 through cavity-ring spectroscopy along with dissolved organic carbon in an intact peat-swamp forest and in a degraded forest in Brunei affected by

7 fires over the last 40 years. We are using natural tracers such as $\delta^{13}C$ and ^{14}C to investigate the age and sources (auto- and heterotrophic) of C contributing to R_{eco} and CH_4 while we are continuously monitoring soil temperature and water table level.

Preliminary data show overall higher R_{eco} in burnt areas (121.3±6.9 mg C m^{-2} hr^{-1}) compared to intact peat-swamp forest (81.5±6.9 mg C m^{-2} hr^{-1}) with no major differences during the dry and wet season. On the other hand, CH_4 efflux show high variability between dry (0.7±0.8 mg C m^{-2} hr^{-1}) and wet season, with a peak in March (27.3±3.1 mg C m^{-2} hr^{-1}). During the dry season intact peat-swamp forest shows lower CH_4 efflux (0.1±0.0 mg C m^{-2} hr^{-1}) compared to burnt areas (1.3±0.5 mg C m^{-2} hr^{-1}) due to a higher water table in the latter. This difference, however, is not evident during the wet season when water table level is similar at both sites.

Carbon dynamics in restored secondary peat swamp forests

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Tropical wetlands such as peat swamp forests (PSFs) have been known globally as one of the carbon (C)-rich ecosystems. However, there is still a lack of understanding of the C cycle in PSFs, especially in association with land use and cover changes (e.g., deforestation, degradation, and restoration). This study presents the C dynamics in terms of changing C stocks, removal, and emissions in restored tropical PSFs in Central Kalimantan. The permanent sampling plots (100 m x 100 m) were established in two restored forest sites and were assessed for their above- and below-ground C-stocks, aboveground primary productivity, total and heterotrophic soil respiration, and ground water level (GWL). It was found that the mean of ecosystem C stocks in the study site was 1,752 ± 401 Mg-C ha^{-1}, of which, 93% was stored in belowground organic peat soils. A mean rate of litterfall of 4.6 ± 0.5 Mg-C ha^{-1} yr^{-1} and biomass growth from tree diameter increment of 2.7 ± 0.5 Mg-C ha^{-1} yr^{-1} were obtained from 1.5 years of data collection. C emission through heterotrophic respiration was as much as 11.1 ± 0.9 Mg-C ha^{-1} yr^{-1}. Hence, these field data were combined with available literature to estimate the magnitudes of C budget and balance tropical PSF. The total estimated NPP was 10.2 Mg-C ha^{-1} yr^{-1} whereas more than 75% of total NPP were composed of the stem and litterfall components. The summation results of NPP and autotrophic respiration represents GPP in this study, which is estimated about 30.3 Mg-C ha^{-1} yr^{-1}. Findings imply that further conservation management efforts through ecosystem restoration may preserve C stored and enhance C input in PSFs substantially, and could be potentially included in national climate change mitigation strategies.

Effects of Litter Inputs on N_2O Emissions from a Tropical Rainforest in Southwest China

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Litter inputs are expected to have a strong impact on soil N_2O efflux. This study aimed to assess the effects of the litter decomposition process and nutrient efflux from litter to soil on soil N_2O efflux in a tropical rainforest. A paired study with a control (L) treatment and a litter-removed (NL) treatment was followed for two years, continuously monitoring the effects of these treatments on soil N_2O efflux, fresh litter input, decomposed litter carbon (LCI) and nitrogen (LNI), soil nitrate (NO_3^--N), ammonium (NH_4^+-N), dissolved organic carbon (DOC), and dissolved nitrogen (DN). Soil N_2O flux was 0.48 and 0.32 kg N_2O-N ha^{-1} yr^{-1} for the L and NL treatments, respectively. Removing the litter caused a decrease of the annual soil N_2O emission by 33%. The flux values from the litter layer were higher in the rainy season as compared to the dry season (2.10 ± 0.28 versus 1.44 ± 0.35 μg N m^{-2} h^{-1}). The N_2O fluxes were significantly correlated with the soil NO_3^--N contents ($p < 0.05$), indicating that the N_2O emission was derived mainly from denitrification as well as other NO_3^--reduction processes. Suitable soil temperature and moisture sustained by rainfall were jointly attributed to the higher soil N_2O fluxes of either treatment in the rainy season. The N_2O fluxes from the L were mainly regulated by LCI, while those from the NL were dominated jointly by soil NO_3^- content and temperature. The effects of LCI and LNI on the soil N_2O fluxes were the greatest in the two months after litter decomposition. Our results show that litter may affect not only the variability in the quantity of N_2O emitted, but also the mechanisms that govern N_2O production. However, further studies are still required to elucidate the impacting mechanisms of litter decomposition on N_2O emission from tropical forests.

Carbon stock and sediment CO_2 efflux changes following mangrove logging and regeneration in West Papua

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Mangrove ecosystems are known for their efficient ability to capture atmospheric carbon. However, these forested coastal wetlands are facing tremendous anthropogenic disturbances

such as land-use and land-cover change (LULCC) including timber harvesting or logging. While timber forest products could generate valuable economic income, the costs and benefits of above-ground biomass removals to biomass carbon stock and soil CO_2 efflux are not yet fully understood. This study investigates the impact of mangrove logging and regeneration to above-, below-ground biomass, and dead downed wood carbon pools, and sediment CO_2 efflux. The field sampling was conducted across 0, 5, 10, 15 and 25 years after logging for carbon stock assessment, and 0, 1, 5, 9, 19 years after logging for sediment CO_2 efflux. Additional site of undisturbed forest was also sampled as study site control for both carbon stock and sediment CO_2 efflux. The preliminary results show significant loss of above- and below-ground biomass carbon stock at zero year since disturbance followed by consistent increase after five years until 25 years since disturbance. In contrast, we find largest amount of dead downed wood at zero year after disturbance that may be attributed to the logging residue. Moreover, we find larger sediment CO2 efflux at zero and first year since logging that may be associated with heterotrophic respiration increase. The field data from our study are essential to update current IPCC carbon emissions factor (EF) for LULCC from coastal mangrove wetlands.

CO_2 and water fluxes from grazed pastures – knowledge gained from comparisons between observations and physiologically-based modelling

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The work presented here studied CO_2 and water fluxes from grazed and mowed pastures. It compared fluxes measured with eddy-covariance methods with the mechanistic ecosystem model CenW. This essentially assessed the consistency between observed fluxes and our mechanistic understanding of whole-sward gas exchange. It includes observations in irrigated and non-irrigated grazed pastures in NZ and in unirrigated grazed and mowed pastures in France. Overall across the different sites and conditions, modelled flux estimates were consistent with all detailed observations.

Evapotranspiration estimates produced particularly good agreement between modelled and observed fluxes, with model efficiencies ranging from about 0.8 to over 0.9. Photosynthetic and respiration fluxes also generally reached good agreement between modelled and measured fluxes with model efficiencies generally above 0.8.

Noteworthy observations included ongoing photosynthetic carbon gain down to temperatures as low as 0°C and significant reductions in photosynthetic carbon gain following grazing that took about 10 days to be fully overcome. These reductions reduced photosynthetic carbon gain to a quarter of rates before grazing.

Grazing events presented particular challenges. It proved difficult to fully capture respiratory carbon losses from grazing cattle that could be an order of magnitude higher than background soil and plant respiration rates. If data points were missing during grazing periods, then reliance on gap-filling routines caused additional problems and uncertainties. Newer approaches have excluded measurements during periods of cattle grazing and have instead provided computational solutions for assessing carbon balances by estimating grazing related carbon losses from measured biomass removal, but that requires highly accurate measurements of those removal rates.

We recommend to always conduct detailed physiologically-based modelling in conjunction with eddy-covariance measurements. It provides an important reality check and facilitates the extraction of generalisable physiological relationships. Changes in gas fluxes in response to various management or environmental conditions can then be simulated.

Plant Transpiration and Water Balance of a Desert Ecosystem in Northwestern China

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Quantification of the plant transpiration and water balance is key to designing management strategies for ecological conservation and water and land resources management in arid regions. We used eddy covariance, sap flow, and stable isotope techniques combined with canopy storage and soil water regime experiments to determine evapotranspiration, plant transpiration, soil evaporation, deep seepage, interception evaporation from canopy in a desert-oasis ecotone in northwestern China. Soil evaporation was determined from the difference between total evapotranspiration and the sum of the scaled sap flow and interception evaporation from canopy. Furthermore, plant transpiration was partitioned between soil water and groundwater by tracing the water sources based on their hydrogen stable isotopic composition ($\delta^{18}D$). Over the entire growing season, total precipitation ranged from 82 to 94 mm, the increment in soil water storage was about 3.0 mm; the ecosystem-level cumulative transpiration, soil evaporation, and interception evaporation at the stand level were from 117 to 146 mm, 55 to 70 mm, 11 to 17 mm, respectively. The total evapotranspiration flux exceeded the corresponding precipitation by 10 up to 66 mm, indicating groundwater was the important water source for plant transpiration and soil evaporation. Transpiration of the dominant shrub species from isotope measurements was composed of between 37% and 80% groundwater. Given the results from isotope measurements and water balance, combined with roots distribution in soil profile, this ecosystem development has a great impact on the local hydrological balance of groundwater.

Carbon and water budgets of irrigated and non-irrigated lucerne for three years from planting

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Agricultural intensification using irrigation and fertilisers impacts soil carbon storage, greenhouse gas emissions, and demand for water resources. Within New Zealand, expansion of dairy farming faces increasing scrutiny over environmental impacts, particularly to freshwater quality and soil carbon stocks; hence there is growing interest in alternative management practices. Lucerne (*Medicago sativa* L.) is an alternative forage crop, with the ability to fix nitrogen from the air and to grow in dry summers due to its deep root system. We continuously measured the carbon (C) and water balance of two neighbouring lucerne fields for three years, following conversion from low-intensity dryland pasture. One field received irrigation water in summer and effluent year-round, the other received neither. In the conversion year, the irrigated lucerne established much better than the non-irrigated lucerne. Irrigation supported enough net CO_2 uptake to compensate for biomass removed by two harvests, plus the C losses from the conversion process. In the second year, both fields were net CO_2 sinks, with 385 and 223 g C m^{-2} uptake for irrigated and non-irrigated lucerne, respectively. However, C export from harvesting exceeded uptake, resulting in net ecosystem losses of C for both fields. In the third year, management included both harvesting and grazing, and ample rainfall increased productivity of the non-irrigated field. By contrast, the irrigated lucerne was heavily affected by the grazing and took up only half as much CO_2 as in the previous year. There was again a net ecosystem loss of C for both fields. Thus, neither management option for lucerne proved advantageous for the aim of increasing soil carbon stocks, compared with conventionally grazed ryegrass-clover grassland. Irrigation increased both the absolute amount of drainage and the fraction of water inputs going into drainage. Irrigation and grazing/harvesting could be managed to improve water-use efficiency and minimise C losses.

Nitrogen budgets for irrigated and non-irrigated lucerne and linkages to the carbon cycle

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Widespread conversion from dryland to intensive dairy farming, with associated increases in animal numbers and effluent, has increased concern over nitrogen (N) leaching into groundwater. Strategies are sought to mitigate impacts on water quality, including the use of alternative forages and targeted irrigation. Seasonal dynamics of nitrogen inputs from fixation by lucerne, effluent application and losses from leaching have been measured in Canterbury,

New Zealand, at an irrigated and a non-irrigated lucerne lysimeter site since September 2016. These sites are representative of widespread land-use conversion on shallow, stony soils within the region. Annual lucerne dry matter production almost doubled with the addition of irrigation and effluent (7.0 and 12.8 Mg DM ha^{-1} for the non-irrigated and irrigated sites, respectively). Preliminary analysis of the annual nitrogen balance shows that, for non-irrigated lucerne with no additional N input, >90% of nitrogen was from fixation. Irrigated lucerne, with 81 kg N ha^{-1} added as effluent, ~70% of plant nitrogen was derived from fixation, with the remainder from the soil and effluent. Annual leaching losses were 16 and 65 kg N and for non-irrigated and irrigated, respectively. The balance of inputs and outputs indicate a net loss of N (as well as carbon, C) from both systems, largely attributable to the export of biomass for stock food. The C:N ratio of leachate from non-irrigated lucerne is ~10, similar to that for soils at both sites, suggesting strong linkages between C and N cycling with no N addition. The C:N ratio of leachate (4.3) under irrigation reflects the C:N ratio of the incoming effluent (3.6). We suggest that timing and frequency of irrigation and effluent application could be optimised to facilitate additional N uptake. Management practices which increase C inputs to the soil may further promote immobilisation of N and reduce N losses.

TERN and OzFlux: Infrastructure, environmental prediction and recent outputs

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TERN is Australia's terrestrial ecosystem observatory. Funded by the National Collaborative Research Infrastructure Strategy (NCRIS), TERN observes ecosystem change from sites to the continental scale, delivering model-ready measurements for enabling environmental research and management. As TERN continues to progress toward providing highly integrated capabilities with the spatial and temporal scope to support Australia's future goal of an environmental prediction system, three platforms have been formed. TERN Landscape Assessment collects and provides spatial data on soils and landscape from remote sensing and modelling sources. TERN Ecosystem Surveillance provides widespread, plot-based collections and data on vegetation composition and structure, soil, eDNA and biodiversity. TERN Ecosystem Processes provides temporal, biogeophysical and process-based information (e.g., fluxes, ecophysiology) from 12 SuperSites nation-wide which are co-located with roughly half of the currently active OzFlux sites. TERN Data Services manage datasets derived from the three platforms of the observatory. This presentation will describe the nature and scope of TERN, TERN's role in Australia's future environmental prediction system and how OzFlux contributes, both as an infrastructure provider and as a research community of practice. This presentation will finally highlight OzFlux outputs since my last report at the 2017 Conference in Western Sydney.

Coordinated in-situ and satellite flux observations over East Asia dryland

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Ecosystem production is a fundamental component of biogeochemical cycles and land-atmosphere interactions at various scales. Semi-arid ecosystems are key contributors to the global carbon cycle and may even dominate the inter-annual variability and decadal trends of the land carbon sink, as demonstrated by several recent studies. Over past years, major achievements have been made to estimate ecosystem productions with satellite data at global and regional scales. However, those estimates were often done with very sparse in-situ data, especially in semi-arid East Asia portion. To better estimate finer resolution primary and ecosystem productions at regional scales, localized field measurements and integration with state-of-art satellite data are necessary. *In-situ* measurements of green vegetation fractions and CO2 flux between land and atmosphere are critical for understanding regional land-atmosphere interactions and for validating satellite data. Here, we integrated multi-scale satellite data and eddy covariance flux measurements from a pilot experiment of coordinated observation with 25 participant field sites to estimate the gross primary production (GPP) and net ecosystem production (NEP) over semi-arid East Asia from site to regional scale at high temporal and spatial resolution. The coordination started with intensive instruments calibration and field survey based on common protocol. We calculated the footprint sizes and landscape heterogeneity over each site with fine resolution satellite data (Landsat and GF) and evaluated the contribution of vegetation patches to flux signals. The vegetation photosynthesis model was driven with satellite derived albedo and EVI and coordinated flux measurements. Generally, the GPP in this region were higher in east and lower in west, with distinguished green spots over oasis and montane forests.

Ecoacoustics - linking faunal biodiversity dynamics to ecosystem fluxes

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Ecoacoustics is a relatively modern development in biodiversity monitoring which uses data from field based audio recorders to investigate natural and anthropogenic sounds and their relationship with the environment. It is only in recent years that it has become possible to unravel the depth of information provided in complex environmental recordings in a meaningful fashion; in particular for long time series data – real big data. While Ecoacoustics is currently unable to provide complete species level identification (frogs, birds, invertebrates)

across the species rich tropical rainforests of North Queensland, the use of false-colour spectrograms and advanced analytics should provide a framework for tracking major changes in community composition. In this presentation our first experiences will be presented on the potential for linking meteorological and ecosystem fluxes as drivers to advanced ecoacoustic analytics.

Comparison of CO_2 Flux Measured Over Crops Using Flux-Gradient and Eddy Covariance Techniques

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In agricultural ecosystems, the flux-gradient technique (FG) is well-suited for measuring CO_2 flux or net ecosystem exchange (NEE) over multiple plots for side-by side treatment comparison. The FG however requires upkeep of a narrow air sample intake (z) to mean canopy height (h_c) to avoid sampling in the roughness sublayer (RSL) and beyond the fetch of the study plot. A study was carried out to compare NEE measured over hay and corn using FG at different z/h_c to NEE measured using the more commonly used eddy covariance technique (EC). Our observations showed that NEE measured using FG at $1.4h_c<z<2.0h_c$ was comparable to NEE measured using EC. Net ecosystem exchange can be measured at z as low as $1.4h_c$ but only under unstable atmospheric conditions as underestimation of NEE measured using FG under stable atmospheric condition has been demonstrated. Frequent adjustments of z during the rapid growth stages of agricultural crops is critical if fetch is limited to avoid sampling in the RSL. However, if maintaining $z/h_c \approx 2$ is not always possible, NEE measured when $1.4<z/h_c$ under stable atmospheric conditions should be scrutinized.

Incorporating non-stomatal limitation improves the ability of leaf and canopy gas exchange models to capture *VPD* responses

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Vapor pressure deficit (*VPD*) is projected to increase in the future. It is thus important to test whether gas exchange models capture the responses of photosynthesis (*A*) and stomatal conductance (g_s) at high *VPD.* We evaluated models against data measured on the Cumberland Plain Woodland, Australia, where *VPD* regularly exceeds 2.5 kPa, and can reach 7 kPa in summer. We tested: (i) empirical and optimal gs models (Leuning, Medlyn), which assume g_s is related directly to *VPD*; (ii) the Tuzet model, which assumes that g_s is regulated by leaf water potential; and (iii) a non-stomatal limitation in which photosynthetic capacity decreases with increasing *VPD*. Model predictions were evaluated at leaf, whole-tree, and ecosystem scales. The comparison with leaf gas exchange data showed that the Medlyn model with non-stomatal limitation outperformed the other tested models and assumptions with fewer parameters (two versus up to six) and similar coefficient of determination (R^2 = 0.7 for *A* and 0.8 for g_s). Incorporating a non-stomatal limitation into the stand scale model MAESPA reduced the over-prediction of transpiration in the previous model without non-stomatal limitation and fitted better to sap flow measurements with R^2 = 0.8 (compared to 0.7). The evaluation against carbon and water fluxes from eddy covariance tower showed improvements in the predictions of ecosystem carbon uptake especially at *VPD* > 2.5 kPa. These findings suggest that models need to incorporate non-stomatal limitation to accurately simulate *A* and g_s at high *VPD*.

Drought Resistance Traits and Thresholds of Forests across TERN Supersites

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Large scale dieback events have profound effects on the biodiversity and ecosystem function with flow on effects to carbon, nutrient and hydrological cycles. Increasing temperatures associated with climate change are likely to cause droughts of greater duration and severity, exacerbating drought induced tree mortality across forest biomes. Recent evidence suggests that Australian vegetation is broadly resilient to drought stress. However, we are currently unable to predict the limits of this resilience in the face of rapid climate change. Making accurate predictions of vegetation response to climate change requires a detailed understanding of the physiological processes that allow plants to cope with drought stress

and their thresholds to mortality. Recent work has demonstrated that the majority of woody plant species across all forest biomes operate close to their physiological safety margins with respect to drought, rendering them vulnerable to future shifts in precipitation and temperature.

The central aim of this study was to determine the limits of drought stress tolerance in Australian tree species across forest biomes. Using the Terrestrial Ecosystem Research Network, we examined key physiological traits related to drought stress tolerance in tree species growing across a broad ecological range.

The results of our work showed a strong relationship between site aridity and hydraulic traits of evergreen tree species growing across Australian forest and woodland biomes. This was reflected in tight coordination between stem hydraulic vulnerability and water stress experienced for different species across sites. These findings demonstrate the importance of hydraulic traits in adaptation to drought and the distributional limits of species with respect to aridity. Hydraulic safety margins were narrower among rainforest species compared with tree species located at more arid sites. This suggests rainforest species operate closer to their hydraulic threshold and may be more vulnerable to extreme climate events.

Adaptive capacity of drought tolerance traits in eucalypts

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Drought is one of the most common environmental stressors and consequently trees have evolved a range of adaptations to tolerate drought. Water relation traits are key in the drought tolerance process but it is not known if trait expression differs between species and which traits have a high degree of plasticity and can change in response to a drought event and which ones are fixed. A greater plasticity can mean a greater adaptive capacity to drought. We investigated water relation traits in different eucalypt species and in populations of a single species in south-eastern Australia. Our results indicate that most water relation traits indeed differed between species, but not all traits were plastic. Eucalypts from more arid environments inherently expressed lower (more negative) turgor loss points (tlp), lower xylem vulnerability (P50), had smaller leaves and a higher Huber Value (sapwood area to leaf area ratio). This indicates that these traits were selected in a long-term evolutionary process and that eucalypts from more arid environments are inherently more drought tolerant. However, only Huber Value and tlp were plastic and adjusted under drought stress, whereas the other traits remained under stress. Within populations of the same species we discovered a different pattern. More arid populations of *Eucalyptus obliqua* had a lower xylem vulnerability and smaller leaves, whereas tlp and Huber Value did not differ among populations. However, under drought more arid populations were able to adjust tlp and Huber Value, indicating that these traits are plastic. Our data indicate that eucalypts are adapted well to drought, but may have a limited capacity to adjust to a rapidly changing climate. Traits with a high degree of plasticity are leaf area adjustment (Huber Value) and decreases in turgor loss point, whereas leaf size and xylem vulnerability are fixed traits.

Carbon and energy fluxes of temperate eucalypt forests in southeastern Australia during the November 2017 heatwave

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Southeastern Australia has experienced several extreme heatwaves since January 2013. Analysis of the energy and carbon fluxes measured at seven sites in the OzFlux Network during the January 2013 heatwave discriminated responses in water-limited dry sclerophyll and Mediterranean woodlands from responses in energy-limited temperate forests. However, there was only one temperate forests (Tumbarumba) included in that analysis. Since then the number of temperate forest sites in the OzFlux network has expanded to three with the addition of Wombat Forest (reassigned from woodland to temperate forest after analysis of its response to a heatwave in 2014) and Warra. Both are *Eucalyptus obliqua* forests. Together the three temperate forest sites provide a latitudinal gradient spanning about 7.5 degrees.

A heatwave event in November 2017 affected the three temperate forest sites enabling a comparison of their energy and carbon fluxes during the heatwave. The energy fluxes of the three sites during the heatwave were comparable. Compared with background conditions in November 2015 and/or 2016, a greater proportion of the available energy during the 2017 heatwave was dissipated as latent heat than sensible heat. This response was consistent with that shown by Tumbarumba and Wombat during the January 2013 and January 2014 heatwaves, respectively.

The carbon fluxes of the three temperate forest sites showed different responses during the November 2017 heatwave. At Tumbarumba net ecosystem productivity (NEP) during the 2017 heatwave was similar to the background period, a response that mirrored the response during the 2013 heatwave. In contrast, NEP at Warra suffered a large (150%) decline during the 2017 heatwave compared with the background period, mostly due to declines in gross primary productivity. The carbon fluxes measured at Wombat showed responses to the 2017 heatwave that were intermediate between those at Warra and Tumbarumba.

Carbon exchanges and their responses to temperature and precipitation in forest ecosystems in Yunnan, Southwest China

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In this study, we employed 29-site-years of eddy covariance data to observe the state, spatio-temporal variations and climate sensitivity of carbon fluxes (gross primary productivity (GPP), ecosystem respiration (R_{eco}), and net ecosystem carbon exchange (NEE)) in four representative forest ecosystems in Yunnan. We found that 1) all four forest ecosystems were carbon sinks (the average NEE was –3.40 tC ha^{-1} yr^{-1}); 2) contrasting seasonality of the NEE among the ecosystems with a carbon sink mainly during the wet season in the Yuanjiang savanna ecosystem (YJ) but during the dry season in the Xishuangbanna tropical rainforest ecosystem (XSBN), besides an equivalent NEE uptake was observed during the wet/dry season in the Ailaoshan subtropical evergreen broad-leaved forest ecosystem (ALS) and Lijiang subalpine coniferous forest ecosystem (LJ); 3) as the GPP increased, the net ecosystem production (NEP) first increased and then decreased when the GPP > 17.5 tC ha^{-1} yr^{-1}; 4) the precipitation determines the carbon sinks in the savanna ecosystem (e.g., YJ), while temperature did so in the tropical forest ecosystem (e.g., XSBN); 5) overall, under the circumstances of warming and decreased precipitation, the carbon sink might decrease in the YJ but maybe increase in the ALS and LJ, whilst future strength of the sink in the XSBN is somewhat uncertain. However, based on the redundancy analysis, the temperature and precipitation combined together explained 39.7%, 32.2%, 25.3%, and 29.6% of the variations in the NEE in the YJ, XSBN, ALS and LJ, respectively, which indicates that considerable changes in the NEE could not be explained by variations in the temperature and precipitation. Therefore, the effects of other factors (e.g., CO_2 concentration, N/P deposition, aerosol and other variables) on the NEE still require extensive research and need to be considered seriously in carbon-cycle-models.

Spatial patterns and climate controls over the phenology and capacity properties of seasonal variation of carbon fluxes across terrestrial ecosystems in China

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Seasonal variation of carbon fluxes in terrestrial ecosystems reflects the dynamic processes in which ecosystems respond to environmental changes. The lack of quantitatively depicting the pattern of both seasonal variation of carbon fluxes and their spatial distributions makes the dynamic simulation of carbon budget with great uncertainty. In this paper, we studied the seasonal variations of carbon fluxes in 15 natural ecosystems from ChinaFLUX, summarized the benchmark modes of seasonal variations of net ecosystem production (NEP), gross primary production (GPP) and ecosystem respiration (RE) of Chinese region. The seasonal dynamics of GPP and RE are unimodal regardless of the climate zones they are in, while the seasonal dynamic of NEP varies greatly with its climate zone. In South Asia monsoon and subtropical zone, NEP presents the dynamic of all year carbon absorption, whereas in regions that locate in Qinghai-Tibet plateau, arid zone, temperate zone and tropical zone, it displays the dynamic of carbon absorption alternates with carbon release. The spatial patterns of phenology and capacity properties of NEP, GPP and RE, and the climate factors that have impacts on the property parameters were determined. Through data integration and analysis, this study maps out the seasonal dynamics of NEP, GPP and RE in major ecosystems in China that provides preliminary understandings of the patterns and environmental impacting factors of seasonal dynamics of carbon fluxes in Asia. Furthermore, it provides insights into understanding regional and global carbon variations and related impacting factors and it also serves as a reference that supplies ecology parameters to other studies in this field.

Spatial and temporal pattern of carbon exchange over ecosystems in China

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Carbon exchange between the atmosphere and terrestrial ecosystems is one of the key processes in biogeochemical cycles that determines the ecosystem functions such as material production and climate regulation. Here, we synthesized the carbon flux observations over China to understand the spatial and temporal pattern of carbon exchange in Chinese terrestrial ecosystems. Our synthesis showed that there was a general temporal dynamic

pattern and clear geographic distribution of annual ecosystem carbon fluxes in China as the result of the combined effects of climate factors pattern.

Predictability of land surface fluxes in FLUXNET 2015

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Previous research has shown that land surface models are performing poorly when compared with relatively simple empirical models, over a wide range of metrics and environments. Atmospheric driving data appears to provide information about land surface fluxes that LSMs are not fully utilising. We use empirical models to exploit the information available in FLUXNET and show that substantial predictive improvement is possible using meteorological data alone, even with no explicit vegetation or soil properties, thus setting lower bounds on a priori expectations on LSM performance. The process identifies key meteorological variables and transformations that provide predictive power. We also assess how predictability varies between sites in FLUXNET 2015 Tier 1 release, and explore site characteristics that affect that predictability. We show that the strongest determinant of predictability appears to be that drier sites tended to be more unique. We found very few other clear predictors of uniqueness across different sites, and in particular little evidence that flux behaviour was well discretised by vegetation type. These results can help land surface modellers make more informed choices of which sites to use for model development and evaluation, and may provide guidance to the FLUXNET community for future flux tower deployments.

SMAP derived soil moisture constrains greenness and photosynthesis of dryland vegetation over central Australia

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An exceptionally extreme wet event in central Australia was recorded in 2010-11, triggering a massive global land carbon sink anomaly, of which half was contributed by Australia. Additionally, another enhanced wet pulse occurred in central Australia during 2016-17, apparently of larger intensity than that of 2010-11. Here we combined multi-satellite observations with eddy covariance measurement to investigate hydro-climate influences on greenness and photosynthesis of two major plant function types (PFTs, mulga woodland and hummock grassland) largely distributed in the arid/semi-arid interior of Australia. The data derived from eddy covariance tower (AU-ASM, Alice Spring Mulga) indicated vegetation productivity of 2016-17 on the same scale as for 2010-11, and winter NEP exceeding previous winters with elevated GEP exceeding carbon emissions. Soil moisture from the SMAP mission,

precipitation from IMERG, and total water storage (TWS) from GRACE were employed to delineate and characterize the evolution of extreme wet pulses, and examine impacts on vegetation dynamics. MODIS enhanced vegetation index (EVI) as a proxy of greenness and satellite solar-induced chlorophyll fluorescence (SIF) from GOME-2 were used, and results show the two PFTs lacked regular seasonal patterns and exhibited high inter-annual variability, especially under intense climates. Trends of greenness and photosynthesis displayed a highly analogous and simultaneous pattern (r^2 = 0.75), of which the peaks were synchronously accompanied with wet pulses. Soil moisture derived from SMAP is proved to be a superior indicator, than precipitation and TWS, of vegetation dynamics, especially for mulga woodland, over central Australia. This study reveals that satellite observations provide worthwhile information on the variability of arid-zone vegetation phenology and productivity to extreme hydro-climates, thus improving our ability to understand and detect ecosystem alteration under future changing climates.

Contribution Title Detection of positive gross primary production extremes in terrestrial ecosystems of China during 1982-2015 and analysis of climate contribution

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Gross primary productivity (GPP) quantifies the photosynthetic uptake of carbon by ecosystems and is an important component of China’s terrestrial carbon cycle and its contributions to the global carbon cycle. Warm temperature extremes and associated droughts significantly reduce ecosystem carbon uptake, but it is not clear whether these historical events are indicative of future global warming impacts on ecosystems. In this study, we used three ecological models: the Boreal Ecosystem Productivity Simulator (BEPS), the Terrestrial Ecosystem Carbon flux model (TEC), and the Global Production Efficiency Model coupled with the Carbon Exchange between Vegetation, Soil, and the Atmosphere model (GloPEM-CEVSA), to simulate China’s terrestrial ecosystem GPP during the period 1982-2015. Years with positive GPP extremes were identified and analyzed for their temperature, precipitation, and solar radiation attributions. We found that maximum GPP occurred in 1990, 1998, and 2013 with the detrended GPP anomalies of 0.36PgC, 0.23PgC and 0.27PgC, respectively. Maximum GPP years were associated with increased carbon uptake in response to increasing temperature and precipitation. China’s subtropical-tropical monsoonal region’s managed forests and agricultural lands had the largest frequency of GPP extremes, which accounted for 45.66%, 49.9% and 45.57% of the total detrended GPP anomalies in the three maximum GPP years, respectively. Land use/land cover with positive GPP extremes were associated with positive radiation and temperature extremes. This study demonstrated that historical climate periods with favorable positive climate extremes and associated increases in

terrestrial GPP may inform predictions of increased carbon sequestration under warming climate projections in some of China's terrestrial ecosystems.

Estimating terrestrial CO_2 fluxes across Asia based on synthesis of AsiaFlux data, remote sensing, and ecosystem modeling

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Estimation of terrestrial carbon budget at country to continental scale is important. A network of eddy-covariance observations is one of the essential data to constrain terrestrial CO2 budget estimation. However, so far, eddy-covariance observation network (e.g. AsiaFlux) has not been used effectively to constrain terrestrial CO_2 budget. In this presentation, we first introduce current status of terrestrial CO_2 budget estimations across Asia. The study includes network of eddy-covariance observation (AsiaFlux), remote sensing data, and terrestrial ecosystem modeling. In addition, we also included data-driven (machine-learning) estimation of terrestrial CO_2 fluxes using ground and satellite observations. We found that overall interannual variations in terrestrial GPP at subcontinental scale is consistent with the satellite-based estimations except for tropical regions. Long-term trend in terrestrial GPP are consistent between data-driven model and ecosystem models if we apply the new MODIS (collection 6) data sets as inputs. Second, we introduce some recent results of terrestrial CO_2 budget estimation through top-down and bottom-up methods comparison. Inter-decadal changes in terrestrial CO_2 budget across Southeast Asia is consistent among remote sensing, bottom-up models and top-down models when the effect of land use changes is considered in the bottom-up models. This study demonstrated that inclusion of land use change improve consistency between top-down and bottom-up estimations of CO_2 budget at sub-continental scales. And these synthesis require further improvement using eddy-covariance observation network datasets, such as data-driven estimations. Therefore, we believe activity and research outputs from AsiaFlux communities are strongly required to improve our understandings of terrestrial carbon cycles.

Derived Optimal Linear Combination Evapotranspiration (DOLCE): a global gridded synthesis ET estimates

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Accurate global gridded estimates of evapotranspiration (ET) are key to understanding water and energy budgets, as well as being required for model evaluation. Several gridded ET products have already been developed which differ in their data requirements, the approaches used to derive them and their estimates, yet it is not clear which provides the most reliable estimates. We present a new global ET dataset and associated uncertainty with monthly temporal resolution for 2000–2009. Six existing gridded ET products are combined using a weighting approach trained by observational datasets from 159 FLUXNET sites. The weighting method is based on a technique that provides an analytically optimal linear combination of ET products compared to site data, and accounts for both the performance differences and error covariance between the participating ET products. We examine the performance of the weighting approach in several in-sample and out-of-sample tests that confirm that point-based estimates of flux towers provide information at the grid scale of these products. We also provide evidence that the weighted product performs better than its six constituent ET product members in four common metrics. Uncertainty in the ET estimate is derived by rescaling the spread of participating ET products so that their spread reflects the ability of the weighted mean estimate to match flux tower data. While issues in observational data and any common biases in participating ET datasets are limitations to the success of this approach, future datasets can easily be incorporated and enhance the derived product.

Poster presentations

Methane and Carbon Dioxide Measurements with New High-Precision Low-Power Low-Maintenance Closed-Path Analyzers: First Lab and Field Results

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By 2017, a new lightweight high-precision closed-path technology was developed with the goal of allowing the WMO-quality measurements of CH_4, CO_2 and other gases with a time response of about 1 Hz or faster, the power consumption of about 15 W, with very minimal maintenance and calibration requirements, and with a relatively low cost.

In 2018, this technology resulted in the development of the first two new models of high-precision gas analyzers, for CH_4 and CO_2 respectively. Both models can enable the multitude of methods and approaches including the following:

- Approaches relying on very high precision CH_4 concentrations, encompassing those often employed by WMO-GAW and EPA communities, such as a family of the Inverse Flux Methods, Lagrangian Modeling, Mass Balance Method, Fence-Line Monitoring, etc.
- Micrometeorological tower methods relying on relatively slow but well-resolved CH_4 concentrations, such as Disjunct Eddy Covariance, Relaxed/Eddy Accumulation, Aerodynamic, Resistance, Integrated Horizontal Flux, Control Volume, Bowen Ratio, etc.
- Eddy Covariance method from towers taller than about 10 m when long intake tubes are deployed.
- Chamber Flux measurements, including both CH_4 and CO_2 from the same CH_4-CO_2-H_2O gas analyzer.
- Distributed Sensors techniques being currently developed for Megacities and Green Cities projects.
- Mobile monitoring, including measurements from various moving platforms.

This presentation will describe key instrument principles and elements of the design, and show first laboratory and field results on CH_4 and on CO_2 from a new high-precision low-power CH_4-CO_2-H_2O gas analyzer (e.g., LI-7810), and CO_2 results from a new high-precision low-power CO_2-H_2O analyzer (e.g., LI-7815).

New Automated Low-Power Flux Measurements and Calculations System Accepting Multiple Anemometer Models

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Growing number of flux stations and networks, larger data streams from each station, and smaller operating budgets require modern tools to efficiently handle the process of flux measurements. These tools should produce standardized verifiable datasets, provide a way to cross-share the standardized data to leverage available funding, and promote data analyses and publications.

In late 2017, the new open-path automated system[1] was developed, based on established models[1,2,3], to simplify hardware configuration, to deploy most careful synchronization available to date[4], to significantly reduce power consumption and cost, and to prevent or considerably minimize flow distortion[5] in the anemometer.

Additionally, the new system incorporates complete automated on-site flux calculations using EddyPro® run by a weatherized remotely-accessible microcomputer providing standardized traceable datasets.

This presentation will describe details and results from the latest field tests of the new flux systems, in comparison to older models and control reference instruments.

Tools for Time- and Space-Synchronized Flux, Weather, Soil and Optical Sensor Network

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Hundreds of flux stations are presently operating as standalone projects and as parts of regional networks. Many have weather and soil data to help clean, analyze and interpret the flux data. However, most do not have optical proximal sensor measurements, do not allow straightforward coupling with remote sensing (drone, aircraft, satellite, *etc.*) data, and cannot be easily used for validation of remotely sensed products, ecosystem modeling, or upscaling from the field to regional levels.

In 2016-2018, new tools to collect, process, analyze and share time-synchronized flux data from multiple flux stations were developed and deployed globally. Originally designed to automate site and data management and streamline flux data analysis, these tools allow relatively easy matching of tower data with remote sensing data.

Additionally, current flux stations can be augmented with advanced ground-based optical sensors and can use standard routines to deliver continuous products (e.g. SIF, PRI, NDVI, etc.) based on automated field spectrometers (e.g., FloX and RoX, etc.) and other optical systems.

Over 100 of new flux stations already operational globally can be readily used for the proposed workflow. Over 500 active traditional flux stations can be updated to synchronize their data with remote sensing measurements.

This presentation will show how the new tools are used by major networks, and describe how this approach can be utilized for matching remote sensing and tower data to aid in ground truthing, improve scientific interactions, and promote joint grant writing and other forms of collaboration between the flux and remote sensing communities.

Monitoring of water stress in rice: Integration of near-surface remote sensing and eddy covariance measurements

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Several risk factors for rice production which tend to increase due to climate change. The precise and rapid forecasting for the impact of the environment on the growth and yield of rice field is important. Eddy covariance (EC) technique is being considered as one of the best micrometeorological methods for the estimation of gross primary production (GPP) and evapotranspiration and as a primary source of data for the development and validation of satellite-based models. Remote sensing, especially satellite data can be used to monitor the variance of structure of plant canopies and yield and has been widely used as a solution to resolve the broad scale estimation of CO_2 flux by upscaling the point measurements of EC technique. Comparisons at flux tower locations can provide used insight into coupling of phenology, ecosystem physiology and remote sensing. This project focuses on the stress of rice by linking the photosynthesis and water use obtained from EC technique, with the reflectance data obtained from Spectro-radiometer on the EC tower, and satellite data. An EC system along with the different biometeorological sensor were established at rice field at RoiEt province, Thailand (15°43’36.6’’N, 103°34’14.2’’E). Different reflectance-based vegetation indexes (VIs) such as NDVI were calculated based on NASA-MODIS spectral bands and correlated with biophysical, biochemical and eco-physiological canopy variables. The relationship between GPP, NDVI and other VIs were analysed. The expected result from these project is an index for health assessment of rice filed in Thailand. Furthermore, these will lead to developing the monitoring system for forecasting and decision support systems in different scale, country, province and famer respectively. The farmers are informed about the problem and can solve the problems in time.

A New Way to Include Soil Water Stress in Terrestrial Ecosystem Models

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To account for soil water stress, a scalar, f_w is usually introduced into the BWB equation to reduce its slope. However, there is no experimental evidence that the use of this scalar in this way is justified. This study firstly quantifies the monthly and diurnal variations in canopy conductance from eddy covariance (EC) flux data at two flux tower sites (US-Var and CA-Oas) representing two plant functional types (grass and forest) by inverting the Penman-Monteith equation. Then, BWB slopes were derived and compared under contrasting water stress conditions by linear regression of canopy conductance and the GPP derived from EC measurements. Finally, the response of V_{cmax} to accumulated soil water deficit (ASWD) was explored to develop a better scheme of soil water stress in a coupled photosynthesis-conductance model. Our results show: (1) the thresholds of relatively available soil water content (RAW) under which soil water stress occurs were 0.61 and 0.65 for US-Var and CA-Oas sites, respectively, derived from a logistic function that is fitted to the observational data; (2) the difference between the BWB slope during wet periods and that during dry periods was not statistically significant, and this difference was much smaller than the inter-annual variations of BWB slopes, indicating that BWB slopes may be conservative under pronged drought; and (3) under prolonged drought, EC-derived GPP gradually decreased with the increase of ASWD, which can be well captured by a V_{mr}-ASWD scheme developed in this study. In sum, the V_{mr}-ASWD scheme would increase the accuracy of GPP simulations of ecosystem models. This study suggests that the use of the f_w scalar is not justified according to the experimental data examined and adjusting V_{cmax} to account for the change in leaf physiology due to prolonged water stress is biologically meaningful and computationally feasible and efficient.

Fluvial export of terrestrial carbon in a seasonally wet tropical catchment

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Understanding the movement of carbon (C) through the landscape is critical for accurate C accounting. Failure to account for the transport of terrestrially-derived C to rivers can result in a considerable over-estimation of the C sequestration by the biosphere. Here we report on the magnitude of fluvial C export in the Howard River catchment, a savanna-covered tropical area of northern Australia. Riverine fluxes of carbon dioxide (CO_2), dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC) were measured at a high resolution over a full year and compared to estimates of net ecosystem production as measured via eddy covariance. Our results suggest that CO_2 evasion was the major process contributing to C loss in the catchment (110 kg C ha^{-1} yr^{-1}), most of which being likely emitted by seasonal wetlands across the catchment. The downstream export of C was dominated by DOC (80 kg C ha^{-1} yr^{-1}), while DIC accounted for 40 kg C ha^{-1} yr^{-1}. These combined C export pathways accounted for about 5-8% of the net ecosystem production of the catchment. Our findings outline the key role of CO_2 evasion in fluvial export, which in future research will need to be quantified directly rather than via simplistic empirical equations.

Eddy Covariance as a tool for monitoring tropical peatland restoration at a catchment scale

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Peatland restoration has become a high priority in Indonesia, due to the devastating effects of peat fires on local and regional public health and economies. The Indonesian Peatland Restoration Agency (BRG) is mandated to restore 2 million hectares of degraded peatlands by 2020. This ambitious initial target will trial a range of methods in a variety of peatland sites. Full peatland restoration, including rewetting the peat, revegetating the land and revitalising local livelihoods, will take decades. In the short to medium term, how can peatland restoration be assessed? With an estimated additional 7 million hectares of degraded peatlands awaiting restoration, the most efficient and effective restoration protocols need to

be identified. In order to pursue successful and cost efficient approaches and adapt and refine less successful restoration techniques, restored peatlands need to be meaningfully monitored and assessed. This project will trial the eddy covariance technique in the harsh environment of degraded peatlands and assess its suitability for monitoring peatland restoration. Fluxes of CO2 and CH4 will account for the majority of the greenhouse gas emissions from peatlands. Restoration aims to rewet the peat soil and revegetate the degraded peat surface, as well as revitalising local livelihoods. The eddy covariance will enable us to directly measure water (evapotranspiration) and carbon fluxes, tracking the changes in hydrology and vegetation growth (carbon sequestration) occurring in in real time at catchment scale. The flux tower will be located in degraded peatlands undergoing restoration within the BOSF Mawas – managed land in Block B of the ExMegaRice Project, Central Kalimantan, Indonesia. These peatlands were drained in 1995-8 and have burned repeatedly in the subsequent 2 decades, most recently in 2015. If the eddy covariance technique proves successful, this approach could empower government agencies (such as the BRG) to monitor and assess the progress of restoration works in the short and medium term.

Eddy covariance flux data quality assessment to evaluate the site in Alpine ecosystem

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Alpine flux tower was established to evaluate the long-term water and mass exchanges between land surface and atmosphere in the Alpine peatland ecosystem. Interpretation of flux tower measurements with eddy covariance method has become widely accepted and powerful tool for the determination of long-term data for the hydrological analysis. Micrometrologycal and physical conditions mainly influence the measurements quality and accuracy. Initially, it is important to estimate measurement accuracy of turbulent fluxes and position and size of surface source areas and the relative contribution of passive scalar sources to measured fluxes. This study aimed to addresses the spatial representativeness of the flux measurements and spatial patterns of data to evaluate year round variability in the Alpine flux tower site. In this study, we assessed wind dynamic and stability over the year and analyzed in the context of Monin-Obukhov similarity theory. A two-dimensional parameterization for Flux Footprint Prediction (FFP) was used to identify footprint contribution of 30 minutes averaged data for each month. Additionally, the percentage contribution of the target land type to the total flux was calculated. Normalized difference vegetation index (NDVI) was used as a key indicator to assess temporal and spatial variability over the area. Annual mean wind roses showed that the prevailing wind directions during the year was north-west to the west and monthly mean revealed that variations of prevailing wind directions were showed high uniformity. According to the stability classes of Obukhov length, the value of 30 minutes average occurrence showed that 50.3% in the very stable stability class. The mean monthly footprint climatology was distributed asymmetrically around the tower and had a similar spatial pattern as prevailing wind direction. The cumulative crosswind month footprints show that about 80% of the flux is from a distance of

100-200m and identify the land classes and weightage within the footprint. The results indicate that; flux tower has a 93.6% annual representative flux contribution of the targeted peatland ecosystem. NDVI distribution in targeted area have shown high seasonal heterogeneity and within the seasons show acceptable homogeneity. These findings provide important information for quality control in flux data for our future studies in Alpine hydrology.

Carbon sequestration capacity fluctuates annually with water deficit in the East Asia Semiarid Grasslands

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Net ecosystem carbon exchange (NEE) in semiarid grassland fluctuates significantly from year to year and has major contribution to interannual variability of the global carbon budget. However, the magnitude of carbon sequestration and the key processes of how climate factors determined NEE dynamics in different biomes are still unclear. In this study, the dynamics of NEE of the East Asia semiarid grassland were observed with two eddy covariance systems, including a meadow steppe in the east of Horqin grassland (TY site), and a typical steppe in Inner Mongolia (MD site) of China. Annual NEE ranged from -67.64 to 55.56 $gCm^{-2}yr^{-1}$ and from -76.61 to 28.40 $gCm^{-2}yr^{-1}$ with standard deviations of 43.78 $gCm^{-2}yr^{-1}$ and 49.93 $gCm^{-2}yr^{-1}$ at TY and MD site, respectively. NEE variability was decomposed into variations in the maximum carbon uptake capacity (NEE_{max}) and length of net carbon uptake period (CUP), and could be better explained by variations in CUP. By mediating CUP and NEE_{max}, precipitation dominated the interannual variablity in NEE. NEE responded more sensitively to decreased precipitation than increased precipitation. Warmer dormant season increased net carbon uptake while warmer growing season decreased net carbon uptake through intensifying water deficit. These findings contribute to accurately understand how climate change will affect carbon dynamics in the East Asia semiarid grassland and how the semiarid grassland feed back to the global C cycle.

Influence of phenological changes on CO_2 uptake and the driving factors in Japanese mountain and alpine ecosystems

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Vegetation phenology is an important index for climate change, and regulates the seasonality of terrestrial carbon balance. As the phenological response varies among species, long-term observations of species-specific phenology in various biomes are necessary for understanding

ecosystem dynamics. To assess the influence of climate change on carbon balance, therefore, we have observed phenology of deciduous needle leaf larch forest, together with CO_2 flux measurements since 2006 at Fuji-Hokuroku flux observation site (1100m a.s.l.). In addition, we have monitored phenology of alpine plants using a digital time-lapse camera since 2009 at Tateyama Murodo (2650m a.s.l.). Because alpine ecosystems are recognized as vulnerable to climate change, however, where it is difficult to measure CO_2 flux due to technical limitations. In this study, we demonstrated the observed phenological changes over a decade and the key factors controlling the changes. Furthermore, the influences of climate change on carbon uptake were evaluated.

Phenology was analysed based on RGB (red, green, and blue) pixel values within images. The start and end of greenleaf season (SGS and EGS) were determined from the temporal trajectory of a greenness index (GR=G/(R+G+B)). Consequently, averaged greenleaf periods were about 195 and 90 days for the larch forest and alpine meadow, respectively, and significant trends were not found. SGS and EGS showed large yearly variations correlated with the spring and autumn temperature, except alpine SGS. In the alpine meadow, the yearly differences of SGS were more than 30 days, affected by the snowmelt timing. In addition, earlier SGS and disturbances by typhoon hits lead to earlier EGS. Earlier SGS and later EGS increased GPP and NEE in spring and autumn. Thus, we suggested GR as an effective index for phenology. Under future climate change, temperature, snowmelt timing and typhoons would be the key factors controlling the dynamics of these ecosystems.

Eddy covariance and biogeochemical observations of methane dynamics in a shallow mid-latitude lake in Japan

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Methane (CH_4) dynamics in a shallow mid-latitude lake in Japan was examined with a combination of eddy covariance and biogeochemical observations. Observations were conducted in Lake Suwa, a eutrophic lake, which has a total area of 13.3 km^2 and a maximum depth of 6.9 m. An eddy covariance system was installed on a pier located on the southeast shore. Relevant atmospheric and lake observations were also conducted. Lake water was sampled at the pier to analyze for dissolved CH_4 concentration profile and to obtain the oxidation rate. Sediment was also sampled to obtain the production rate. The eddy covariance CH_4 observation revealed that both steady and sporadic ebullition emission, in addition to diffusive emission, occurred in this lake. The steady ebullition occurred in a specific area and its maximum emission was up to 2.0 μmol m^{-2} s^{-1}. The seasonal variation of steady ebullition was negatively correlated with total hydrostatic pressure. The seasonal variation in diffusive CH_4 emission was controlled by water temperature: the typical emission of 0.3 μmol m^{-2} s^{-1} in summer and 0.1 μmol m^{-2} s^{-1} in winter. On the shorter time scale,

diffusive CH_4 emission increased with wind speed, suggesting that the emission was influenced by the transport efficiency in the water column. We also proposed a technique to partition the total fluxes into diffusive and ebullitive emissions. Both CH_4 production and oxidation rates became higher with an increase of incubation temperature, reflecting the temperature dependence of microbial activity. The oxidation rate was also positively correlated with initial dissolved CH_4 concentration, suggesting a limitation by substrate availability. Dissolved CH_4 concentration showed the highest concentration in early summer, with a higher concentration in deeper layer due to the stable stratification. These biogeochemical observations will be used in interpreting the flux variations and in improving a lake simulation model.

Seasonal Variations of Surface Energy Exchange and Evapotranspiration over a Shrubland of an Oasis-Desert Ecotone in Arid Regions of Northwest China

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Quantification of the energy and water vapor exchange at the land-atmosphere interface are critical for determining local and regional hydrological processes in arid regions, where water resources is routinely scarce. Here the surface energy fluxes and evapotranspiration (ET) were observed using eddy covariance along with other meteorological measurements, at an ecotone between oasis and desert in the middle part of the Hexi Corridor regions of northwestern China. The majority (80%) of available net radiation (R_n) at the surface was dissipated as sensible heat (50%) and soil heat flux (30%), while only 8% of R_n was consumed by latent heat flux (λE). The emergence of leaves or increase in leaf area index greatly alters the partitioning of net radiation into sensible heat, latent heat, and soil heat fluxes. Prior to leaf emergence, latent heat flux (2%) was typically a minor component of the surface energy budget, and the Bowen ratio was large (20). At leaf area index peak (0.28), latent heat flux increased up to 20% of R_n, and the Bowen ratio declined to nearly 2. Evapotranspiration is limited by soil moisture, and has a pronounced annual cycle and its annual maximum rate of ET is about 3.6 mm d^{-1}, in response to changes in temperature, precipitation, and leaf area index. Accumulated annual evapotranspiration was 195 mm, exceeding precipitation by about 87 mm, indicating that some of dominant shrubs may use deep soil water recharged by capillary rise from the saturated to the unsaturated zone, and may even directly use groundwater given that the depth to groundwater for the site is relatively shallow (i.e., 4.5 m below the ground surface).

Effect of veterinary antibiotics on NH_3 volatilization from rice-wheat field

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Veterinary antibiotics have been widely detected in croplands in China due to the application of animal excrements as fertilizer; however, their effects on ammonia (NH_3) volatilization remain unclear. To study the effects of veterinary antibiotics sulfamethazine (SMZ) in different concentrations and their interactions with different basal fertilizer conventional synthetic fertilizer (CF) and pig manure (M)) on NH_3 volatilization from cropland, an in-situ observation experiment was conducted during the 2016-17 rice-wheat season. Five treatments in the rice season included no fertilizer and no SMZ applied (CK), the CF and M used as basal fertilizer respectively, with 0, 30mg/kg soil SMZ respectively (CF, CF+SMZ30, M, M+SMZ30). The treatments in the winter-wheat season included CK, CF used as basal fertilizer, with the addition of 0, 5, 15, 30mg/kg SMZ respectively (CF, CF+SMZ5, CF+SMZ15, CF+SMZ30), M used as basal fertilizer, with the SMZ at the same concentrations (M, M+SMZ5, M+SMZ15, M+SMZ30). Urea was applied as topdressing in all fertilizing treatments. The results showed that no matter what kind of fertilizers was applied, SMZ obviously promoted NH_3 volatilization rate in the topdressing stage. During the entire rice observation period, the proportions of applied N lost as NH_3-N (EF_{NH_3}) for CF, CF+SMZ30, M and M+SMZ30 was 6.8%, 11.2%, 4.0% and 11.1%, respectively. During the winter-wheat observation period, the EF_{NH_3} for CF+SMZ5, CF+SMZ15, CF+SMZ30, M+SMZ5, M+SMZ15 and M+SMZ30 treatments was 5.5%, 6.6%, 13.9%, 10.7%, 11.0%, 12.4%, 11.9% and 16.9%, respectively. In comparison with the same basal fertilizer and no SMZ use treatment, CF+SMZ15, CF+SMZ30 and M+SMZ30 significantly increased cumulative NH_3 volatilization ($P<0.05$). This indicated that the effect of veterinary antibiotic on NH_3 volatilization in soils cannot be ignored. It's necessary to further explore the mechanism of different veterinary antibiotics affecting soil NH_3 volatilization in the future.

On Developing a Visualization Assistance Tool for the Dynamical Process Networks

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The information flow dynamical process network (DPN, Ruddell, B. L., Kumar, P., 2009. Ecohydrologic process networks: 1. Identification. Water Resources Research 45, W03419) analysis can describe ideally complex ecohydrologic/biogeochemical processes such as methane emission mechanisms for rice paddies. The DPN is defined as a network of feedback loops and the associated time scales, where the variables in a system are cast as nodes and

information flows as weighted directional links between nodes. Since the DPN describes emergent properties of the system resulting from forcing and feedback couplings, it can show how ecosystems respond and adapt to environmental changes. Agrometeorological measurements from an eddy covariance flux tower can produce suitable time series data with a high temporal resolution for the DPN analysis. Even though it is an innovative approach to analyze such data, it is not still widely used due to difficulty in visualizing the DPN using the quantified information statistics (i.e., mutual information and transfer entropy). In this presentation, we introduce the development process of a visualization assistance tool for the DPN to alleviate the difficulty.

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Response of fine root respiration rate and morphology along a subalpine elevation gradient in Japan forest

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Root respiration 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 root function such as growth and resource uptake. Because alpine climate such as cold-temperature and snowfall gives stress for plant behaviour, fine roots should adapt the structure and function along the elevation gradient. Here, we elucidated root respiration and morphology of fine roots in response to elevation gradient and their relationship between the respiration and morphology of Birch (Betula ermanii) and Fir (Abies veitchii and Abies Mariesii), which dominated in Japanese subalpine forest.

We established three plots along the gradients on the east slope of Mount Norikura in central Japan. We measured respiration of fine root system from three elevations (1600m, 2000m, 2300m) in summer during August, 2017. The fine roots were evaluated as root respiration under constant temperature and morphological traits such as specific root length (length per drymass) and root tissue density (drymass per volume).

Root respiration rate was significantly differed between species, with higher rate of Birch. However, there was no change in the respiration among the elevation gradients. In the morphological traits, specific root length and root tissue density were also significantly differed between species, but did not change along elevation gradients. There were no significant difference in the relationship between the respiration and morphology among the elevation. On the other hand, the root respiration rates were positively correlated with specific root length and negatively correlated with root tissue density across the gradients. Thus, the physiology and morphology of fine root in our site at the growing period were same in spite of different elevation. These results showed that fine roots in growing period of subalpine climate might exhibit species-specific maximum resource-acquisition ability by changing the structure and function

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 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. These uptake rates varied with VOC species and plant species. *S. clevelandii* absorbed phenol and benzyl alcohol more rapidly than low molecular weight ketones and aldehydes. We also found that the *S. clevelandii* leaves exposed to phenol emitted anisole. It might be produced by methylation of phenol inside the leaf.

Leaf photosynthetic capacity significantly correlates with leaf chlorophyll content in subtropical evergreen coniferous plantation

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Photosynthesis is arguably the most important biochemical process and photosynthetic rate is a key source of uncertainty in modelling carbon cycles. Recent studies have focused on the key role of leaf chlorophyll content in photosynthesis. However, few studies have concentrated on the relationship between leaf photosynthetic capacity and leaf chlorophyll content in evergreen coniferous forests. In this study, we evaluate the relationship between both maximum rate of carboxylation (V_{cmax25}) and maximum rate of electron transport at 25°C (J_{max25}) and leaf chlorophyll content in slash pine (Pinus elliottii Engelm.) and native Masson pine (Pinus massoniana Lamb.). CO_2 responses of leaf photosynthesis were measured using a

Li-6400 gas-exchange system during 2017. Leaf chlorophyll content and leaf nitrogen were also measured at Qianyanzhou Ecological Station. Our results showed that there were no obvious seasonal changes in leaf nitrogen content in MP and SP. While large temporal variations in V_{cmax25} and J_{max25} were found over the growing season. There was a weak or even no correlation between leaf nitrogen content and V_{cmax25} in both previous-year and current-year leaves. Leaf total nitrogen content cannot be a good proxy for photosynthetic capacity because of the dynamic and large proportion of nitrogen in nonphotosynthetic machinery and changing fractions within photosynthetic machinery. We found a significant correlation between V_{cmax25} and leaf chlorophyll content in previous-year and current-year leaves for both species ($P<0.001$). However, the relationship between photosynthetic capacity and leaf Chl varies according to leaf age in our study. Incorporating the effects of leaf ages within process-based models can reduce the uncertainties in simulating carbon uptake in evergreen forests.

Response of net ecosystem production to interannual rainfall variability in an old-growth eucalypt woodland

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The Great Western Woodlands is globally unique for its extensive, relatively intact woodland landscapes that grow up to 20 m tall on as little as 280 mm mean annual rainfall. Most other temperate woodlands have been extensively cleared for agriculture. Its relatively intact state provides a great opportunity for understanding how temperate woodlands function. From January 2013 to December 2017 we measured net ecosystem productivity (NEP) in 20 m tall, sparse (LAI = 0.3), old-growth woodland dominated by eucalypt species including *E. salmonophoia* and *E. salubris*. Raw eddy covariance data were acquired at 10 Hz. Quality control and gap filling of data, and partitioning of NEE into net ecosystem respiration and gross primary productivity using the Lloyd-Taylor method, were performed using PyFluxPro. Carbon storage has not yet been measured at this remote site. During the first two years of measurement rainfall was well above average (351 - 378 mm) and NEP was strongly positive (0.42 - 0.76 ton C ha^{-1} $year^{-1}$). During 2015 – 2017, rainfall was near or below average (208 – 312 mm) and NEP was -0.38 to -0.54 ton C ha^{-1} $year^{-1}$, indicating that the carbon sequestered during the previous two years was rapidly released back to the atmosphere. After five years the cumulative NEP was -0.17 ton C ha^{-1}. Nearly half of all annual rainfall from 2013-2017 fell in the months January-March. This region is expected to experience increased annual rainfall, mainly in summer, as a result of climate change. Our results suggest that a sustained increase of rainfall could increase the NEP of this old-growth woodland. Large trees in old-growth woodland have significant stores of carbon in biomass. Longer term measurements, and measurements of carbon storage, are required to test whether the old-growth woodland will be a net source or sink of carbon under future climates.

A comparison on data gap-filling between panel data and Artificial Neural Networks

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Continuous and high-quality data are essential in environmental sciences to detect trends, analyse physical processes and make precise predictions. TERN OzFlux provides ongoing eddy covariance flux and meteorological data streams for use in environmental science. However, the data provided by this network have gaps from hours to days and even months that make it difficult to be used for scientific analyses and particularly for estimating annual sums of water balance and carbon sinks/sources. Hence, to provide a continuous time series with both fluxes and environmental drivers these gaps must be filled. Here we explore how we can improve the gap-filling results by considering the dynamic nature of the whole network, determining the effects of unlooked-for events and avoiding overtraining by using an approach called panel data (PD). Panel data analysis is a method of studying a particular subject within multiple sites, periodically observed over a defined time frame. We applied the model to various meteorological drivers, e.g. precipitation, soil temperature, air temperature, etc. to test the capability of panel data for gap filling particularly with respect to existing methods such as Artificial Neural Networks. We present preliminary results regarding these meteorological drivers and compare it with those of ANNs. The 30-minute flux data collected at Howard Springs, Tumbarumba and Calperum sites during 2016 and 2017 were chosen to apply and validate the model as these sites were good samples of tropical climate, mid-latitude forests and semi-arid ecosystems in a raw. Then we compared the gap-filling results of meteorological drivers with those using Artificial Neural Networks. We found that Artificial Neural Networks had a minor superiority over panel data in general whilst in some cases PD was superior, e.g. soil temperature at Howard Springs. Overall, this research shows developing a hybrid model using both ANNs and PD might improve gap-filling results.

Using a paired tower approach and remote sensing to assess energy distribution in heterogeneous ecosystems

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Remnant vegetation in expanding urban areas is often fragmented, highly managed and under constant threat of land-use-change. The greater western Sydney region hosts the endangered Cumberland Plain woodlands, a dry sclerophyll forest where two dominant Eucalyptus species (*E. moluccana* and *E. fibrosa*) grow in mixture with a common subdominant tree species, paperbark (*Melaleuca decora*). To assess the spatio-temporal dynamics of energy partitioning within the heterogeneous Cumberland Plain SuperSite, we placed a mobile flux tower (AU-MoFO) in a paperbark stand within 300 m distance of the main flux tower (AU-Cum). We then used airborne LiDAR to characterise vegetation structure within the footprint of each tower and characterised temporal dynamics of vegetation phenology using Landsat 8. Differences in vegetation structure manifested in contrasting seasonal patterns of sensible heat (H) and latent heat fluxes (LE). Consequently, we revealed contrasting Bowen ratio (BR) dynamics over distances as short as 300m. Daytime H and LE peaked in summer and declined towards winter at both sites. However, LE remained consistently larger at AU-Cum than AU-MoFO, whereas H at AU-Cum exceeded H at AU-MoFO only during winter. Seasonal patterns of energy distribution shifted the BR from being dominated by LE in winter, towards being driven by H in summer and remaining balanced in spring and autumn. Canopy-to-atmosphere coupling (CTAC) of LE and H was higher at AU-MoFO, particularly for LE. Further, CTAC of H increased, while CTAC of LE decreased from winter to summer at both towers. Our observations demonstrate that energy distribution varies with vegetation structure, as canopy properties of dense paperbark stands are distinct from taller, more open canopies of dominant eucalypts. Variable vegetation properties within dry sclerophyll forests should be considered in modelling the ecosystem energy balance, especially in the context of increasing urbanization and fragmentation.

Plant chlorophyll fluorescence: active and passive measurements at canopy and leaf scales under different water availability

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Recent studies have demonstrated that solar-induced chlorophyll fluorescence (SIF) can offer a new way for directly estimating the terrestrial gross primary production(GPP). Soil moisture is a critical index that significantly affect the plant growing and exchange of water between plant and atmosphere. However, its detailed trait of active and passive fluorescence at canopy and leaf scale, and their responses to different soil moistures have not been reported. In this study, we presented continuous ground measurements of SIF at 760nm over six plots of wheat with different irrigation treatments. The results showed that active and passive measurements were highly correlated over the growing season across water treatments at both canopy and leaf-average scale. The active and passive measurements reach their maximum value at earlier time in less soil moisture than that in normal soil moisture. The ability of sensitivity of SIF to the status of soil moisture decrease with the decrease in chlorophyll content. Chlorophyll fluorescence can be used to better estimate plant photosynthetic capacity under different water available and therefore to provide improved information for crop management.

Seasonal dynamic of evapotranspiration of rubber tree (*Hevea brasiliensis* Müll.Arg.) plantation in a different part of Thailand

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The seasonal dynamic of evapotranspiration (ET) for 3-rubber tree plantations was observed over a year (2017) by using eddy covariance measurement and micrometeorological estimation techniques. The observation was conducted at Chachoengsao province (CC-RF), Bueng Kan (BK-RF), and Nakorn Si Thammarat (NST-RF) in the east, noth east and south of Thailand, respectively. The observation sites were a monoclonal stand of rubber trees (*Hevea brasiliensis* Müll.Arg.) clone RRIM 600. The rubber tree in CC-RF, BK-Rf, and NST-RF were 23, 8, and 17 year, respectively. Rubber trees in all observation site were tapped. The results showed that total annual of ET was 1011, 1176, and 1168 mm for CC-RF, BK-Rf, and NST-RF, respectively. For CC-RF and NST-RF, the total monthly ET for the dry season (Jan. – Feb. and Nov. - Dec.) was low (<100 mm), while total monthly ET for the transition (Mar.-Apr. and Oct.-Nov.) and wet season (May-Sep.) was higher. While the seasonal dynamics of BK-Rf was different from the other two due to it age was lowest, and just started of tapping.

Satellite chlorophyll fluorescence captures heat stress for the winter wheat in the Indian Indo-Gangetic Plains

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Extreme high temperature represents one of the most severe abiotic stress limiting crop productivity. However, understanding the crop responses to heat stress is still limited under the increasing heatwaves in both frequency and severity. This is partly due to the lack of timely and effectively monitor of crop responses to extreme heat at a broad scale. In this work, we used the recent available space-borne sun-induced chlorophyll fluorescence (SIF), a new proxy of photosynthesis, along with traditional vegetation indices (EVI and NDVI) to investigate the impacts of heat stress on winter wheat in the northwestern India, one of the world's major wheat production areas. High determination coefficient between satellite SIF and crop-yield at the large level (R^2=0.77, whole study area) and the small level (R^2=0.61, county scale) indicate that SIF can be a good proxy for the wheat yield. The remarkable

consistency between SIF and the heat stress in 2010 during wheat grain-filling and harvesting stage at the spatial and temporal scale demonstrate that SIF has a high sensitivity and can monitor heat stress on wheat timely. Furthermore, our results show that SIF can provide large-scale physiology-related wheat stress response as indicated by the larger reduction in fluorescence yield (SIFyield) than fraction of Photosynthetically Active Radiation during the grain-filling phase, which may have eventually led to the reduction in wheat yield in 2010.

Comparison of infrared canopy temperature in a rubber plantation and tropical rain forest

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Canopy temperature is a result of the canopy energy balance and is driven by climate conditions, plant architecture, and plant-controlled transpiration. Here, we evaluated canopy temperature in a rubber plantation (RP) and tropical rainforest (TR) in Xishuangbanna, southwestern China. Infrared temperature sensor was installed at each site to measure canopy temperature. In the dry season, the maximum differences (Tc – Ta) between canopy temperature (Tc) and air temperature (Ta) in the RP and TR were 2.6 K and 0.1 K, respectively. In the rainy season, the maximum (Tc – Ta) values in the RP and TR were 1.0 K and –1.1 K, respectively. There were consistent differences between the two forests, with the RP having higher (Tc – Ta) than the TR throughout the entire year. Infrared measurements of canopy temperature can be used to calculate canopy stomatal conductance in both forests. At mid-day, stomatal conductance (gc) values in both forests were typically about double the single leaf values. The difference in (Tc – Ta) at three gc levels with increasing direct radiation (DR) in the RP was larger than in the TR, indicating that change in (Tc – Ta) in the RP was relatively sensitive to the degree of stomatal closure.

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 drivers, such as net radiation, vapor pressure deficit, soil water content and leaf area index,

but these drivers complexly affect the variation of ET. In this study, we examined controls on ET from a red pine ecosystem, 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, Fujiyoshida, Yamanashi, Japan. The sensible and latent (LE) heat flux were measured using eddy covariance technique on the forest floor and above the canopy.

A seasonal variation of ET was mainly driven by net radiation (Rn) and vapor pressure deficit (D). The annual maximum above-canopy LE was observed in August and the monthly average was about 90 W m^{-2}. Meanwhile, a monthly average of forest-floor LE was the highest in May and the value was about 10 W m^{-2}. Leafing of within-canopy deciduous trees started in June, which subsequently decreased forest floor Rn and in turn LE.

A short-term variation of forest-canopy LE was controlled by D and wind speed (U). Therefore we made an empirical formula with D and U, and estimated forest-floor LE. Estimates of summertime (June-August) LE were relatively close to observed LE, and the RMSE of daily average was 2.64 W m^{-2}.

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

Rainfall pulse response of carbon fluxes in a temperate grass ecosystem in the semiarid Loess Plateau

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Rainfall pulses can significantly influence carbon cycling in water limited ecosystems. The magnitude of carbon flux component responses to precipitation may vary depending on precipitation amount, antecedent soil moisture and energy input, associated with nonlinear responses of plants and soil microbes. The present study was carried out in a temperate grass ecosystem during 2013–2015 in the semiarid Loess Plateau of China, to examine the response of carbon fluxes to precipitation using the “threshold-delay” model. The unique contribution of environmental variables, such as precipitation amount, antecedent soil moistures (SWC_antecedent) and relative exchange photosynthetically active radiation to carbon fluxes in response to rainfall were also investigated. The lower threshold of effective rainfall was 6.6 mm for gross ecosystem production (GEP), 8.5 mm for net ecosystem production (NEP) and 4.5 mm for ecosystem respiration (RE). Rainfall amount was the main influencing factor and positively affected the relative rainfall responses of GEP, NEP and RE. However, SWC_antecedent at 20 cm soil depth offset the response of GEP and NEP to rainfall pulses, and SWC_antecedent at 5 cm depth offset the response of RE to rainfall pulses, with corresponding partial slopes of linear regressions of −0.34, −0.37 and −0.31. These results

indicated that RE was more sensitive to rainfall pulses, followed by GEP and NEP. These results demonstrate the importance of rainfall events of < 10 mm, and that the negative effect of SWC_antecedent should also be considered when estimating ecosystem carbon fluxes in this semiarid region.

EC measurements of N_2O fluxes from grazed pasture identify temporal patterns and environmental controls

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Nitrous oxide (N_2O) is a potent agricultural greenhouse gas derived in part from nitrogen-rich animal excreta deposited onto soils, yet our understanding of the environmental controls on N_2O fluxes has mainly come from small-scale experiments, for example, static chamber measurements on plots or lab incubations. So far, studies of the environmental controls for N_2O fluxes at ecosystem scales have been limited because of technological challenges. We incorporated a quantum cascade laser into a novel temperature-controlled environmental housing to make continuous eddy covariance (EC) measurements of N_2O fluxes for a one-year period at a farm grazed year-round by dairy cows in the Waikato region, New Zealand. Our measurements consistently showed significant N_2O flux pulses associated with rainfall following grazing events during warm-dry months. In contrast, during cold-wet months when WFPS was consistently high, N_2O pulses after rainfall did not occur. We identified an optimum soil moisture/temperature zone that favours maximal N_2O emissions at ~70% water-filled pore space (WFPS) and moderate soil temperatures. Distinctive diurnal flux patterns emerged in both pulses and background fluxes, implying that soil temperature regulates N_2O fluxes at sub-daily timescales. A clear positive temperature response for N_2O fluxes was observed above 70% WFPS while a negative relationship was detected when WFPS was less than 70%. Over the annual period, N_2O emissions were 6.5 kg N_2O-N ha^{-1}. We found the highest cumulative rates (maximum 35.7 g N_2O-N ha^{-1} day^{-1}) in autumn but the rates were low during both summer and winter.

Effects of Different Short-Term Stresses on Aggregate Compositions, Enzyme Activities and Microbial Communities of Banana Orchard Soil

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In recent years, many banana orchards were devastated by Fusarium wilt disease. Extreme weather often appeared, such as drought, waterlogging, acid rain, and invasion of pathogenic microorganism in the planting region, etc., these factors play an important role in the occurrence of banana wilt disease. In this study, according to lab simulation experiment, the

effects of different types of short-term stress on the soil structure and function of banana garden were studied. Soil samples were collected from a banana orchard in Hainan, China. The distribution of soil aggregates and enzyme activities were analyzed after the soils were cultured under various conditions such as drought, wet, acidification and pathogen invasion (*Fusarium oxysporum*). Soil aggregates (>2, 2-0.25, 0.25-0.053 and <0.053 mm) were separated by wet sieve method. Compared with the control, the proportion of water-stable macroaggregates (>0.25 mm) significantly decreased except for the >2 mm macroaggregates under acidification, while microaggregates (< 0.25 mm) increased significantly in all the treatments, the activities of soil invertase, urease, phosphatase and catalase were reduced by 20%-90%, and bacteria populations were also significantly reduced. Acidification and pathogen invasion significantly increased the numbers of *F. oxysporum* from 10^2 CFU/g to 10^3 CFU/g and 10^4 CFU/g respectively. MiSeq sequencing analyses indicated that soil microbial community structure was also significantly changed. On the bacterial phyla level, the relative abundances of Acidobacteria, Bacteroidetes, Gemmatimonadetes in the soils treated with drought, wet, acidification and pathogen invasion were significantly lower than those in the control soil. On the fungal phyla level, the relative abundances of Ascomycota in soil treated with drought, acidification and pathogen invasion were significantly higher, however, Ascomycota in soil treated with wet were reversed, compared to the control. Thus, adverse environmental factors can seriously affect soil quality, e.g., aggregate formation, soil enzyme activities and microbial community composition.

CO_2 balance in a northern bog located in the southern border of climatogeneous peatland zones, northern Japan

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Northern peatlands, characterized by grass, *Carex*, and *Sphagnum* peat, accumulate dead plant as peat under cool and humid conditions. However, climate warming can alter the productivity and decomposition, and can eventually degrade the carbon sink function of the peatlands. Northern Japan is located in the southern border of climatogeneous peatland zone in the northern hemisphere. Increased decomposition rate can restrict the peat accumulation. However, the carbon balance of such peatlands have not been quantitatively evaluated. In this study, CO_2 flux and environmental factors such as micrometeorological, soil thermal and hydrological conditions were monitored in the Bibai mire, a preserved bog located in the central part of the Hokkaido Island, northern Japan in 2015 and 2016. Annual net CO_2 balance (NEE), gross primary production (GPP), and ecosystem respiration (RE) were respectively -150 to -180, 1330 to 1410, and 1180 to 1230 gC m^{-2}. The NEE was more negative (greater carbon sink) than those in bogs in central Europe. The GPP and RE were also greater than those in European bogs. From the obtained data, we evaluated the carbon balance and its responses to the meteorological and soil conditions

Dissolved Organic Carbon of Degraded Peat Soil with Sulphidic Substratum and Its relationship with Groundwater Level: A case study of Block C Ex-Mega Rice Project

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Dissolved organic carbon is a component of ecosystem carbon flux that cannot be captured by above ground flux measurements. However, in high rainfall and high carbon ecosystems, such as tropical peatlands, it may be anticipated that dissolved organic carbon could comprise an important component of total carbon fluxes. The objectives of this research was to study dissolved organic carbon (DOC) concentration of peat water resulting from the difference in hydrological condition and the peat thickness overlaying sulphidic substratum. The study was carried out in the degraded peatlands within Pangkoh area, in block C of the Ex-Mega Rice Project. Peat water was sampled via PVC pipes installed on each plot representing different peat thickness (deep, medium and shallow peat) at depths of 25, 50, 100, 150, 200 and 250 cm below the soil surface. The measurements were conducted at three time points: at peak wet season, transition from wet season to dry season and peak dry season. The results showed that DOC was influenced by peat thickness, depth of sulfidic material, and groundwater level. The deep peat released more DOC than the shallow and medium depth peat. The concentration of DOC in the dry season is higher than in the rainy season and the transition season. This study suggests that peatland have important role as organic carbon pool in tropical ecosystem, and its potentially release large amounts carbon into environment as waterborne losses. Maintaining the peat remains wet through maintaining the groundwater level is one effort to reduce carbon release in form DOC. This study also will inform current and future above ground eddy covariance flux measurements in tropical peatlands in this region.

The effects of sun-viewer geometry on sun-induced fluorescence and its relationship with gross primary production

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Gross primary production (GPP) from photosynthesis by terrestrial vegetation is the largest sink of atmospheric CO2. It dominates inter-annual net biome productivity and contributes most to uncertainties in current global vegetation models and thus carbon cycle projections.

Sun-induced chlorophyll fluorescence (SIF) has been shown a powerful proxy for photosynthetic activity and used to estimate GPP. However, both non-physiological and functional factors controlling the emission of canopy SIF. The non-physiological factors, especially the sun-viewer geometry, impact the relationships between SIF and GPP. In this study, we did near-surface observations of both carbon flux and multi-view-angle spectra above a wheat canopy. The carbon flux was used to calculate GPP and the canopy spectra were used to retrieve red and far-red SIF. SIF observed at three view azimuth angles (i.e. 90º, 180º, 270º, defined from geodetic south), with view zenith angle same as solar zenith angle or 40º when solar zenith angle is bigger than that, are selected to analyze the effects of view angle on SIF observation. Based on data obtained on a sunny day, the diurnal cycle of red SIF with different view azimuth angles shows larger variance than that of far-red SIF. In addition, red SIF is more correlated with the angle between sun and viewer than far-red SIF (R^2=0.71, R^2=0.63, respectively). These results indicate that red SIF is more sensitive to sun-viewer geometry. The relationships of red and far-red SIF with GPP are also changing with different view angles. Generally, SIF observed at 180º are more correlated to GPP than that at the other two angles. Furthermore, the closer to hotspot SIF observed, the closer correlation founded between SIF and GPP. These results suggest that effects of sun-viewer geometry on SIF observation need to be corrected for estimation of GPP.

Attribute parameter α characterized the seasonal variation of gross primary productivity: Spatio-temporal variation and influencing factors

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The interannual and geospatial variabilities of annual gross primary productivity (AGPP) of terrestrial ecosystems are important biological components that affect the function of ecosystem carbon sinks and its response to climate change. However, the mechanism for the spatial and temporal dimensional variations of AGPP remains incomplete clear. Here we defined a new ecological parameter αGPP (the ratio of mean daily gross primary productivity (GPPmean) to maximum daily gross primary productivity (GPPmax)) to characterize the seasonal dynamic patterns of GPP. In this study, 953 site-years of GPP and its seasonal dynamic parameters (GPPmax , GPPmean and αGPP) from 116 flux sites in Northern Hemisphere. The results showed that the αGPP of terrestrial ecosystems in the Northern Hemisphere varied in the range of 0.47 to 0.85 with an average of 0.62±0.06. The αGPP of wetlands were significantly lower than those of forests, grasslands and shrubs. From the tropics to polar zones, αGPP gradually decreased. The 70% of the αGPP-variation derived from its geospatial variation and only 30% from its interannual variability. The αGPP in all climatic zones and ecosystem types showed stable interannual variabilities, while largely decreased with latitude increasing on the geospatial pattern. The spatial pattern of seasonal attribute of astronomical radiation(αQ) is the dominant factor affects the spatial pattern of αGPP, for its controls on the spatial patterns of seasonal attribute of temperature(αT). The

results provide quantitatively spatial and interannual variabilities of the essential seasonal dynamic parameters of GPP that would be useful for the accurate assessement of regional and global AGPP.

Recent Advancements in Closed-Path Eddy-Covariance Flux Systems: Faster-Response Design, Field Auto Zero/Span, and Online Full Corrections

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The Campbell Scientific closed-path eddy-covariance (CPEC) system has been recognized and used as the benchmark standard to verify CO_2/H_2O flux measurements in recent publications and among FLUXNET, Asiaflux and other flux networks; therefore, the CPEC systems are being adopted into newly established high standard networks (e.g. New York MesoNet) for performance reliability and data quality, even in rugged environmental conditions. CPEC systems used to have the disadvantages of greater attenuation in frequency response and high requirement for power. Recently, the new improved series of CPEC300 has been released from Campbell Scientific, including three models: CPEC300, CPEC306, and CPEC310 (most advanced version). The series is fastest in frequency response among CPEC sensors (e.g. 4.3 Hz cutoff frequency), is equipped with field auto CO_2/H_2O zero/span module as a user option, and is implemented with field full corrections by EasyFlux-DL-CR6CP. These CPEC models also feature the advancements of vortex intake to reduce field maintenance for lens cleaning, low power consumption (i.e. total 12 W) to reduce the use for solar panels or other power sources, and fast air temperature calculation to improve estimation for atmospheric variables. This poster addresses these advantages and the integration of CPEC310 with AP200 systems, where AP indicates Atmospheric Profile, into forest ecological systems for long-term CO_2/H_2O flux monitoring in the super tower network facilities in Qingyuan CERN Laboratory at the Institute of Applied Ecology, Chinese Academy of Sciences.

Evapotranspiration partitioning and its characteristics for winter wheat based on the concept of underlying water use efficiency in the Loess Tableland of China

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Evapotranspiration (ET) partitioning is one of the most important issues in water transport process of terrestrial SPAC and water resources management. The underlying water use efficiency (uWUE) model could effectively separate plant transpiration (T) from ET and solve problems of the mismatch among soil evaporation (E), T and ET in spatial scales and the difficulty in continuous measuring of T and E in the now available experiment observations. T/ET was estimated by the ratio of an apparent uWUE ($uWUE_a = GPP \cdot VPD^{0.5}/ET$) to a potential uWUE ($uWUE_p = GPP \cdot VPD^{0.5}/T$). This study partitioned the ET of winter wheat on the Loess Tableland using eddy covariance data and analyzed the characteristics of T/ET at different time scales during growing seasons. In order to solve the problem of $uWUE_a$ anomaly on a half-hour scale, the upper limit of $uWUE_a$ was chose as data-filter threshold based on the requirement of average daily T/ET not more than 1. The planting system of Loess Tableland is one harvest a year, and winter wheat was grown continuously in the experimental years. The growing season average T/ET of winter wheat in the years of 2005-2006, 2007-2008 and 2008-2009 are 0.50, 0.67and 0.58, respectively. The dynamic change of five days average of T/ET within the growing season showed a bimodal pattern, while the ET rate was low before regreening stage and then increased rapidly. ET rate reached the maximum at booting stage, which was 5.48, 5.66 and 6.23mm/day, respectively. The first peak of T/ET appeared in the tillering stage with the average of 0.56, and the ET for the corresponding time were 0.76, 0.46 and 0.39mm/day, respectively. The second peak occurs around the booting stage and exceeded 0.80 in all three years, and the ET for the corresponding time were 3.02, 3.11 and 3.81 mm/day, respectively.