AsiaFlux Mini-Workshop on Remote Sensing and Ecological/Environmental Monitoring

2-4 March, 2016

National Taiwan University, Taiwan

Welcome to AsiaFlux Mini-Workshop on Remote Sensing and Ecological/Environmental Monitoring!

Over the last two decades, various methods have been developed to monitor greenhouse gasses and a number of studies, using different sources of data, have also been conducted to better understand the spatial and temporal distributions of greenhouse gases. Remote sensing data acquired by Earth observation satellites have proven to provide useful data for characterizing greenhouse gases distributions. In particular, the Greenhouse Gases Observing Satellite (GOSAT), the world's first Earth observation satellite dedicated to greenhouse-gas monitoring, has been providing data of greenhouse-gas concentrations to research communities since 2009. On the ground level, numerous greenhouse gas flux monitoring sites have been established since late 90's. In this mini-Workshop, we will introduce the characteristics of the greenhouse-gas flux data observed by flux towers and concentration data observed by remote sensing satellites, and researchers from both communities will share their research experiences and findings to stimulate further collaborations and future directions of greenhouse gases monitoring studies.

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AsiaFlux
National Taiwan University
Chi-Sing Irrigation Association
Chi-Seng Water Management Research & Development Foundation
Taiwan Agricultural Engineers Society

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Program of the AsiaFlux Mini-Workshop on
Remote Sensing and Ecological/Environmental Monitoring
(2-4 March 2016; National Taiwan University, Taiwan)

Wednesday, 2 March 2016: Day 1

Opening	***Chair: Akira Miyata (NIAES, Japan)***
09:00-09:30	*Opening addresses*
	Kuo-Yen Wei (Minister, Environmental Protection Administration, Executive Yuan, Taiwan)
	Ching-Chang Chang (Council of Agriculture, Taiwan)
	Shih-Wen Chou (Chi-Sing Irrigation Association, Taiwan)
Session I: GOSAT	***Chair: Nobuko Saigusa (NIES, Japan)***
09:30-10:00 (*invited*)	Hiroshi Takagi (NIES, Japan)
10:00-10:20	Hibiki Noda (NIES, Japan)
10:20-10:40	*Discussion*
Coffee/tea break	
Session Ⅱ:Towards upscaling of ground-based fluxes (I)	
	Chair: Nobuko Saigusa (NIES, Japan)
11:00-11:30 (*invited*)	Chandra Shekhar Jha (ISRO, India)
11:30-11:50	Abhishek Chakraborty (ISRO, India)
11:50-12:10	Taibanganba Watham (ISRO, India)
12:10-12:30	Pramit Kumar Deb Burman (IITM, India)
12:30-12:50	*Discussion*
Lunch	
Session Ⅲ: Towards upscaling of ground-based fluxes (Ⅱ)	
	Chair: Shenggong Li (CAS, China)
14:30-15:00 (*invited*)	Shaoqiang Wang (Chinese Academy of Sciences, China)
15:00-15:20	Lei Zhou (Chinese Academy of Sciences, China)
15:20-15:40	Yanmu Li (Chinese Academy of Sciences, China)
15:40-16:00	Reiko Ide (NIES, Japan)
16:00-16:20	Yuan Shen (National Chung Hsing University, Taiwan)
16:20-16:40	*Discussion*
16:40-18:30	***Report discussion group / NTU excursion group***
18:30-20:30	***Welcome Reception***

Thursday, 3 March 2016: Day 2

Session Ⅳ: Towards upscaling of ground-based fluxes (Ⅲ)

Chair: Ke-Sheng Cheng (NTU, Taiwan)

09:20-09:40	Cheng-yen Chen (National Taiwan University, Taiwan)
09:40-10:00	Jennifer Khattar (National Dong Hua University, Taiwan)
10:00-10:20	Shih-Chieh Chang (National Dong Hwa University, Taiwan)
10:20-10:40	*Discussion*

Coffee/tea break

Session Ⅴ: Ecological monitoring ***Chair: Lulie Melling (TPRL, Malaysia)***

11:00-11:20	Nazarin Ezzaty binti Mohd Najib (Universiti Teknologi Malaysia, Malaysia)
11:20-11:40	Sawaid Abbas (The Hong Kong Polytechnic University, Hong Kong)
11:40-12:00	Dony Julius (APRIL, Indonesia)

Lunch

Session Ⅵ: Ecological monitoring (continued)

13:40-14:00	M Golam Mahboob (Bangladesh Agricultural Research Institute, Bangladesh)
14:00-14:20	Yonggang Chi (Chinese Academy of Sciences, China)
14:20-14:40	Ma. Carmelita R. Alberto (IRRI, Philippines)
14:40-15:00	Jinghua Chen (Chinese Academy of Sciences, China)
15:00-15:20	Herman Maraden (APRIL, Indonesia)
15:20-15:40	*Discussion*

Coffee/tea break

Session Ⅶ: Estimating terrestrial carbon exchange on the global scale

Chair: Joon Kim (SNU, Korea)

16:00-16:30 (invited)	Kazuhito Ichii (JAMSTEC, Japan)
16:30-16:50	Kazutaka Murakami (NIES, Japan)
16:50-17:10	*Discussion*

Closing

Field Trip to Flux site
(Friday, 4 March 2016)

Site name	Guandu Nature Park Flux Station
AsiaFlux site code	GDP
Location	Guandu Natural Park, Taipei City, Taiwan
Position	121° 28' E, 25° 07' N
Elevation	4 m above sea level
Slope	0 %
Terrain type	Grass marsh
Climate	Cfa
Mean annual air temperature	23.0 °C
Mean annual precipitation	2405.1mm
Vegetation type	Grass
Domestic species (Overstory)	Brachiaria mutica (Tower 1); Phragmites australis (Tower 2)
Canopy height	1.2m (Tower 1); 3.0m (Tower 2)
Soil type	Clay

Abstract

An overview: GOSAT-based CO_2 observation and the application of GOSAT data in understanding changes in surface CO_2 fluxes on regional scales

Hiroshi Takagi, Shamil Maksyutov, and Tatsuya Yokota

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Since its successful launch in early 2009, the Greenhouse gases Observing SATellite (GOSAT) has been making global measurement of reflected sunlight spectra from which column-averaged CO_2 concentrations (X_{CO2}) are retrieved. The GOSAT X_{CO2} values, retrieved under clear-sky conditions, have been utilized together with surface-based CO_2 data in the estimation of surface CO_2 fluxes on sub-continental and ocean-basin scales (42 terrestrial and 22 oceanic regions). The results of the flux estimation have been made public as the GOSAT Level 4 data product by the National Institute for Environmental Studies GOSAT Project. We herein present the overview of the GOSAT Level 4 flux estimation approach and the obtained regional-scale CO_2 fluxes and their uncertainties. Also touched in this presentation are examples of how the satellite-based CO_2 data can be applied to monitoring changes in terrestrial vegetation; we will present reviews of recently published studies in which GOSAT X_{CO2} data were utilized to see how CO_2 uptake by terrestrial vegetation responds to large scale weather anomalies occurred in northwestern Eurasia and central Australia.

Overview and future perspective of GOSAT and GOSAT-2

Hibiki M. Noda, Yukio Yoshida, Makoto Saito, Isamu Morino, Osamu Uchino, Shamil Maksyutov, Masataka Ajiro, Tsuneo Matsunaga, Tatsuya Yokota*

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In recent decade, global worming has been progressed because of the increase of atmospheric concentration greenhouse gasses (GHGs) such as carbon dioxide (CO_2) and methane (CH_4). Thus it is necessary to monitor and evaluate concentration and GHGs flux in both local and global scale. To measure CO_2 and CH_4 globally, Greenhouse gases Observing SATellite (GOSAT) was launched on January 23, 2009 and has been operated by Japan Aerospace eXploration Agency (JAXA), Ministry of the Environment of Japan (MOE) and National Institute for Environmental Studies (NIES) for about seven years. It measures the column-averaged concentrations of CO_2 and CH_4 from 56,000 locations on the Earth's atmosphere. In addition to GHGs concentration, solar induced chlorophyll fluorescence (SIF) emitted by terrestrial vegetation has been also observed by TANSO-FTS, a GHGs observation sensor of GOSAT. Since SIF is related to the photosynthetic activities and physiological conditions of the plants, it would be a new strong tool to evaluate the ecosystem functions.

In this presentation, we will review the results of GOSAT and discuss the future collaborations between AsiaFlux network and GOSAT and/or GOSAT-2, a successor to GOSAT.

Use of satellite remote sensing in monitoring mass and energy exchange with conjunctive use of Eddy Covariance flux towers data – ISRO's National Carbon Project perspective

Chandra Shekhar Jha, Kiran Chand Thumaty, Suraj Reddy Rodda and Vinay Kumar Dadhwal

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Energy In the recent years, increasing levels of CO_2 against normal background levels and the subsequent impact on the rising global temperatures has become much of a research concern. Increase in CO_2 levels is believed to be one of the primary drivers of climate change and calls for more understanding of C-cycle at varying levels/tiers of biosphere-atmosphere exchange. Carbon primarily exists in the carbon pools of earth system (reservoirs – eg. vegetation, atmosphere, soil and ocean) or in the form of movement/exchange (flux) between these reservoirs. In an integrated system, the fluxes connect reservoirs together to create cycles and feedbacks. Therefore it is necessary to study periodically, the land, atmosphere and oceanic processes as a reliable means to understand major carbon pathways and thus the C-cycle at a global scale.

Satellite remote sensing based monitoring of C-cycle components such as estimation of gross primary productivity (GPP), vegetation and soil carbon, atmospheric CO_2 concentrations etc. at spatial (regional and global scales) and temporal scales is very relevant in analysis and modelling of different land-ocean-atmospheric C-processes. The present study details on the research activities being carried out as part of National Carbon Project (NCP), which is envisaged to assess the carbon pools and fluxes over major ecosystems of India and to assess the net carbon exchange using satellite remote sensing and ground based measurements.

In the present study, evaluation of two types of remote sensing based GPP models i.e. models based on estimating GPP from absorbed photosynthetic active radiation (APAR) at 1) canopy level and 2) green leaf or chlorophyll level has been carried out using conjunctive use of eddy flux tower derived GPP for central Indian deciduous forests and Sundarban mangroves (evergreen forests). Calibration and validation of the models showed a very strong correlation ranging from $R^2 = 0.8 – 0.9$ between estimated and observed GPP values, suggesting the potential use of remote sensing data in estimating spatial GPP. Further, spatial estimates of forest above ground biomass have been carried out using optical, synthetic aperture radar (SAR) data sets and plot level (ground inventory) estimates. Results suggested potential use of satellite remote sensing in estimating forest above ground biomass and thus vegetation carbon pools. The paper also discusses on the potential of remote sensing data in energy partitioning and estimation of evapotranspiration with conjunctive use of eddy flux tower data for different forest ecosystems of India.

Quantifying carbon flux over low land tropical rice ecosystem of India and upscaling it using temperature-grenness model

Abhishek Chakraborty[1], Karun Kumar Choudhary[1], K V Ramana[1], P Srikant[1], M V R Seshasai1, V K Dadhwal[1], G Annapurna, Ch Srinivas[2]

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Rice is the major food crop in Asia, occupying about 87 % of the world's total rice cultivated area as per the Food and Agricultural Organization. Within it 80 % is grown under flooded conditions (Towprayoon et al. 2005). Rice is a staple food for more than 65% of population in India. Rice cultivation is highly wide spread and practiced under vast range of climatic, edaphic and biological conditions with different agricultural management practices which in turn determine the CO_2 and energy fluxes from it. Tropical low land flooded rice is a unique ecosystem in term its gaseous exchange and energy partitioning, thus plays a crucial role in the global budget of greenhouse gases. Thus, an Eddy covariance system along with the different bio-meteorological sensor were established at Regional Agricultural Research Station, Maruteru, West Godavari to measure net CO_2/H_2O fluxes from flooded rice ecosystem. The eddy data and micro meteorological observations during *rabi* 2014 were analyzed to calculate half hourly fluxes using Eddypro software with dynamic metadata to accommodate changes in the crop height. Further, Net Ecosystem CO_2 Exchange (NEE) was gap filled and partitioned into Ecosystem respiration (RE) and Gross Primary Productivity (GPP) using R-eddyPro. Temperature-Greenness (TG) model was used to scale up the daily mean GPP of flooded rice field. It estimates GPP as a product of scaled Enhanced Vegetation Index (EVI) or canopy greenness and scaled Land Surface Temperature (LST) or environmental down-regulation.

The NEE showed considerable diurnal and seasonal variation. The mean NEE varied from +4.33 to –12.58 μmol CO_2 m^{-2} s^{-1} , where, positive sign indicated net CO_2 emission into the atmosphere and negative sign denote net CO_2 assimilation or uptake by the crop. The rice paddy ecosystem was behaving as a CO_2 source during night hours and a CO_2 sink during the day. Almost over the entire season, on daily basis, crop behaved as net CO_2 sink except few days during just after transplantation and few days in the maturity stage. The average NEE in the Vegetative Stage (1-15 DAT) i.e. +0.25 gC m^{-2} day^{-1}, signifying the rice crop to be weak net CO_2 sink. Then it gradually became more negative or strong net CO_2 sink in the tillering to panicle initiation stage (16-35 DAT) i.e. -3.96 gC m^{-2} day^{-1}. The reproductive stage (36-60 DAT) was found to have highest rate of CO_2 influx i.e. -8.86 gC m^{-2} day^{-1}, whereas the heading to flowering stage (61-65 DAT) had influx of -7.73 gC m^{-2} day^{-1}, and Ripening (66-90 DAT) stage of -3.05 gC m^{-2} day^{-1}. During the harvesting stage (91-95 DAT) the rice crop acted as a carbon source with average NEE of 1.95 gC m^{-2} day^{-1}. Throughout the *rabi* season the net ecosystem CO_2 exchange was found to be -409.55 gC m^{-2}.

Total 39 cloud free MODIS EVI and LST images were obtained during the *rabi* season of 2014. Among these images 29 were used for model calibration and 10 were used for model validation. The product of scaled EVI –LST was derived and zonal mean of it were extracted over the fetch of the flux tower. The scaled EVI-LST product was linearly regressed with the respective daily mean GPP. Significant correlation ($p=0.05$) was obtained with R^2= 0.74 and slope (m) 2.97. The relationship was further utilized to map the daily mean GPP over the surrounding four districts i.e. West Godavari, East Godavari where similar kind of agricultural practices are followed for rice cultivation. The rice mask was used to identify the rice pixel. The T-G model based GPP was further validated with observed GPP and strong relationship was obtained with R^2=0.79 and SEE = 0.14 mol C m^{-2} d^{-1}. The study demonstrated the usefulness of TG model to upscale the GPP over tropical flooded rice ecosystem and also its capability to capture the spatio-temporal variations of GPP. Future study would be extended on the other crops (cotton and ground nut) towards quantifying their ecosystem exchanges.

Estimating gross primary productivity over a moist sal forest using remote sensing and CO_2 flux tower measurements

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Shorea robusta (sal) is a native species on Indian subcontinent, occurs in both deciduous dry and moist forests and in evergreen moist forest. Sal forest accounts for 14% of the total Indian forests. Understanding how these forest interact with the prevailing microclimate, and quantification of the carbon source/sink by these forests are vital for estimation of Indian carbon budget and management. The study was conducted on Barkot Flux Site (BFS), which is a sal dominated forest located between 30°03′52′′- 30°10′43′′ N and 78°09′49′′- 78°17′09′′ E. The average carbon stock of the forest site was found to be approx. 270 Mg C ha-1. A year-long Eddy covariance (EC) measurement data was used for the study of carbon fluxes. EC data was analysed and gap-filled through MDS technique to estimate the annual net ecosystem exchange (NEE) for the site. Later, the day-time respiration (RE) was obtained using the exponential function between night-time NEE and night-time air temperature developed for each 8-day interval (as per MODIS pass date). The day-time RE was added to –NEE for obtaining the gross primary productivity (GPP). The obtained GPP was used for calculating light use efficiency (LUE). 8-day averaged LUE was calculated as a function of GPP, fraction of absorbed photosynthetically active radiation (FAPAR) and photosynthetically active radiation (PAR), i.e. LUE = GPP/FPAR×PAR. Half-hourly average values between 10:00 to 14:00 hours were used for the calculation of LUE to synchronize with MODIS pass time. Tower measured half-hourly solar radiation was converted to PAR. FAPAR was obtained using MODIS data derived vegetation indices. The highest (maximum) LUE value (emax) was used in EC-LUE model (Yuan et al., 2007) for spatio-temporal upscaling of GPP for the entire Barkot forest using 500×500 m MODIS pixel. GPP was calculated as, GPP = emax × FAPAR × PAR × Ps (Phenology scalar) × Ws (Water scalar) × Ts (Temperature scalar). Air temperature measured at 32 m height was used for scaling temperature. Ws and Ps were derived using LSWI (Land Surface Water Index). The model obtained GPP value was validated against tower-obtained GPP. The same emax value and methodology will be tested for rest of north Indian sal forest.

Key Words: EC-LUE, emax, GPP, MODIS, NEE, LSWI.

Kaziranga national park: latest entrant to Indoflux, Indian fluxnet community

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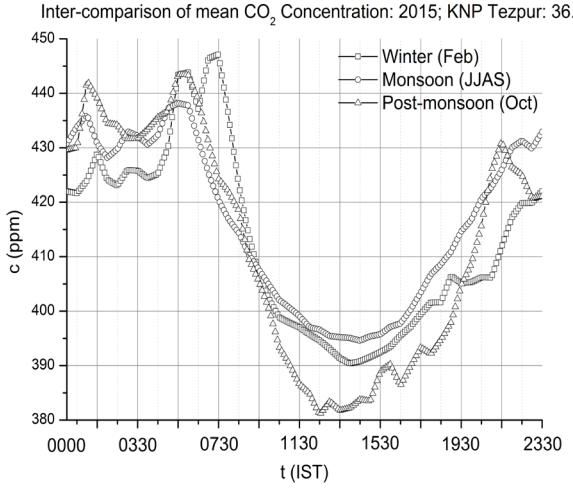
Kaziranga National Park (here onwards abbreviated as KNP) is located at north-eastern part of India which has a humid subtropical climate (Cwa) according to Köppen classification. Semi-evergreen, moist deciduous forest is characteristic of this place with an average canopy height of 20m. A 50m tall micrometeorological tower has been erected in this area in joint collaboration between Indian Institute of Tropical Meteorology (IITM), on behalf of Ministry of Earth Sciences (MoES), Government of India and Tezpur University to monitor fluxes of CO_2, water vapour and energy among land, surface layer and upper atmosphere. This tower hosts multi-level instrumentation which includes 1) EC systems at two levels (7.3m and 36.6m, below and above canopy, respectively), 2) multi-component weather sensors at four levels (3.8m, 7.1m, 20.1m and 36.9m), 3) air-CO2 profiling at eight levels (2.1m, 4m, 6m, 8.1m, 12m, 16.1m, 20.1m and 36.4m), 4) soil temperature and moisture sensors at five depths (surface, 5cm, 15cm, 25cm and 40cm), 5) soil-CO2 flux measuring system at four corners of the site, 6) soil heat flux plate at 5cm, 7) net radiometer, 8) IR thermometer, 9) PAR, 10) line-PAR, 11) dew-point generator and 12) LAI measurement.



Due to remoteness of the site physical, electrical and internet connectivity have remained major problems in terms of setting up the tower, operating it as well as collecting the data in regular interval. Moreover, this forest hosts two-thirds of world's great one-horned rhinoceros including other endangered fauna and thus has been listed as an UNESCO World Heritage Site making activities such as setting up tower etc. to be restricted and allowed only after ensuring proper security measures by forest guards. Especially, during Indian summer monsoon this area receives heavy rainfall causing the site to be water-logged. However, after continuous striving for more than one year most of the instruments started producing meaningful, realistic and continuous data.

The results to be presented by the author in this mini-workshop are quite elementary in nature. However, they are derived out of first generation data produced at this site. No previous data has been reported from any other site having the climate as well as vegetation type similar to KNP. Moreover, temporal span of the data covers three distinct seasons namely, winter, monsoon and post-monsoon. Hence, distinct inter-seasonal signatures are captured in the result making it scientifically valuable. As an example mean diurnal variations of CO_2 concentration ('c' here onwards) during all these seasons have been compared in the adjoining figure. Minimum value of c observed during monsoon is 395ppm which decreases further to 380ppm during post-monsoon suggesting enhanced photo-synthetic activities after a wet season. Moreover, it is again seen to gradually increase up to 390ppm in winter as the canopy being semi-deciduous shades leaves during this time and photo-synthetic activity gets reduced. More results including fluxes of CO_2, water vapour and energy will be presented in this work. Additionally, radiation data including PAR and LAI will be shown to draw robust conclusion regarding plant activities.

Narrowband bio-indicator monitoring of temperate forest carbon fluxes in northeastern China

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Developments in hyperspectral remote sensing techniques during the last decade have enabled the use of narrowband indices to evaluate the role of forest ecosystem variables in estimating carbon (C) fluxes. In this study, narrowband bio-indicators derived from EO-1 Hyperion data were investigated to determine whether they could capture the temporal variation and estimate the spatial variability of forest C fluxes derived from eddy covariance tower data. Nineteen indices were divided into four categories of optical indices: broadband, chlorophyll, red edge, and light use efficiency. Correlation tests were performed between the selected vegetation indices, gross primary production (GPP), and ecosystem respiration (Re). Among the 19 indices, five narrowband indices (Chlorophyll Index RedEdge 710, scaled photochemical reflectance index (SPRI)*enhanced vegetation index (EVI), SPRI*normalized difference vegetation index (NDVI), MCARI/OSAVI[705, 750] and the Vogelmann Index), and one broad band index (EVI) had R-squared values with a good fit for GPP and Re. The SPRI*NDVI has the highest significant coefficients of determination with GPP and Re (R_2 = 0.86 and 0.89, $p < 0.0001$, respectively). We compared the GPP spatial patterns inversed from our model with corresponding results from the Vegetation Photosynthesis Model (VPM), the Boreal Ecosystems Productivity Simulator model, and MODIS MOD17A2 products. The inversed GPP spatial patterns from our model of SPRI*NDVI had good agreement with the output from the VPM model. The normalized difference nitrogen index was well correlated with measured C net ecosystem exchange. Our findings indicated that narrowband bio-indicators based on EO-1 Hyperion images could be used to predict regional C flux variations for Northeastern China's temperate broad-leaved Korean pine forest ecosystems.

Keywords: narrowband bio-indicator; carbon fluxes; temperate broad-leaved Korean pine forest; EO-1 Hyperion; remote sensing

Estimation of light-use efficiency based on flux measurements and spectral observations in mid-subtropical planted coniferous forest of China

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The photochemical reflectance index (PRI) calculated from spectral reflectance has universally become a proxy for the light-use efficiency (LUE), which significantly improves the LUE-based estimation of ecosystem gross primary productivity on a large scale through upscaling. In this study, we observed the vegetation spectral reflectance of a planted subtropical coniferous forest from the top of a flux tower at Qianyanzhou Station in September and December 2013, and simultaneously measured CO2 flux and meteorological variables for analysis. Results showed that PRI had a better correlation with LUE (R2=0.20, P<0.001) than that of normalized difference vegetation index (NDVI), i.e., PRI was preferred in LUE retrieval. During the whole observation period, PRI and soil water content (SWC)-based bivariate regression model correlated well with LUE (R2=0.29, P <0.001; R2=0.30, P <0.01 for daytime and midday observation, respectively). But in autumn the bivariate regression model of PRI and vapor pressure deficit (VPD) had a higher correlation with LUE (R2=0.448, P <0.001) for midday observation. This study showed that environmental factors, i.e. SWC and VPD, had a potential in improving the LUE retrieval from PRI, but the choice of appropriate environmental factors depended on season. To improve the accuracy in estimating LUE, factors such as the water conditions of the atmosphere and soil should be considered in future studies.

Analysis on the relationship between photochemical reflectance index (PRI) and light-use efficiency (LUE) in subtropical coniferous forests

Yanmu Li and Shaoqiang Wang

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Energy of plants intercepted or absorbed through photosynthesis transformed into organic dry matter, the efficiency of this process is known as light use efficiency(LUE). It is not only the important concept of vegetation photosynthesis ,but also one of the important parameters whose estimation model is used to research Gross Primary Productivity (GPP) and Net Primary Productivity (NPP) of ecosystems at different scales. The photochemical reflectance index (PRI) derived from spectral measurements provides a new method for directly estimating the light-use efficiency (LUE).Several studies showed good relationships between LUE and PRI derived from remote sensing of most boreal forests. However, studies on light-use efficiency in subtropical coniferous forests presently use flux data rather than remote sensing method. This study intends to integrate eddy covariance flux measurements with vegetation reflectance measurements from canopy, calculate PRI at site level using data from automated multi-angular spectro-radiometer (AMSPEC system) and develop the relationships between PRI and LUE calculated from the flux data. Analyze the variation of the relationships between PRI and LUE on diurnal and seasonal scale in subtropical coniferous forests. We find that the relationship between PRI and LUE is most closely in winter(R^2=0.633) , tighter in summer(R^2=0.324) and the tightest in summer(R^2=0.245). We will explore the reasons that influence the relationships between PRI and LUE. To see if the study Gamon did in evergreen conifers can adapt to the situation in subtropical coniferous forests.

Key words: photochemical reflectance index, light-use efficiency, AMSPEC system, diurnal and seasonal scale

Necessity of masking devices to exclude contaminated reflection for tower-based measurements of spectral reflectance from vegetation canopy

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Plant canopy spectral reflectance is measured at many flux observation sites to estimate the canopy's biophysical and physiological features. When a wide-angle downward-facing spectrometer is used for tower-based measurements of reflected irradiance, it also captures reflections from a flux tower and near-horizon light from the sky within the focus of view, leading to incorrect canopy reflectance estimates. However, the effects of this contamination have not been quantified so far. Therefore, in order to measure canopy reflectance more accurately and to access the effects of the contamination, we developed a masking device for excluding the contaminated reflections. The device consisted of a detachable masking cap, which automatically rotates around the spectral sensor to allow measurements of canopy reflectance both including and excluding tower reflections. Then canopy reflectance of a Japanese larch (Larix kaempferi) forest was continuously observed on the flux tower by using the device in masked and unmasked modes. In this study, we describe the masking device's design and demonstrate how tower contamination affected the measured canopy reflectance. The contamination effects were serious and complex, and the magnitude varied depending on wavelength, time of a day, season, and weather conditions. The canopy reflectance in the visible spectral region was largely overestimated by a maximum of more than 3 times the actual value due to tower contamination, especially in autumn under clear sky condition. Meanwhile, the infrared reflectance was weakly affected. Consequently, vegetation indices were greatly affected due to the tower contamination, for example, the normalized-difference vegetation index (NDVI) was underestimated by 7 to 22% during the growing season. For precise measurements of canopy reflectance with using wide-angle sensors, such as spectral radiometers and PAR sensors, therefore, we strongly recommended the use of such a masking device.

Derivation of landscape coefficients from latent heat flux measurements and reference evapotranspiration retrieved from meteorological satellite data

*Ming-Hwi Yao[1], Ming-Hsu Li[2], Jehn-Yih Juan[3], Yue-Joe Hsia[4], and Yuan Shen[5]**

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Reliable quantification of evapotranspiration (ET) is very important in planning and management of freshwater resources. Although substantial amount of remote sensing algorithms have been proposed to provide ET mapping at different time and spatial scales, their wide application have been limited by the inaccuracy of retrieved land surface temperature under cloudy conditions and/or requirements of auxiliary ground and atmospheric observations. Alternatively, estimates of ET may be derived by multiplying reference evapotranspiration (ETo) with properly determined landscape/crop coefficients. In this study estimates of pan evaporation, derived from surface solar radiation retrieved from meteorological satellite images by Heliosat-3 method, multiplied by empirically derived pan coefficient for Taiwan region were used to produce ETo maps at a 10-day time scale. Comparing with the ETo computed by the FAO-56 Penman–Monteith method, the overall relative mean bias deviations (MDB%) and root mean square differences (RMSD%) were only about -3.5% and 7.7%, respectively. Long term data of latent heat flux measured by Eddy Covariance methods at four different landscapes, paddy rice (Oryza sativa), subtropical cypress forest (Chamaecyparis obtusa var. formosana and Chamaecyparis formosensis), warm-to-temperate mixed rainforest (Cryptocarya chinensis, Engelhardtia roxburghiana, Tutcheria shinkoensis, and Helicia formosana), and grass marsh (Brachiaria mutica and Phragmites australis), in conjunction with the derived ETo maps, were then used to determine landscape coefficients (KL) for corresponding landscapes. The scheme can easily be applied to other locations where data of long term ET fluxes measurements are available. More fluxes measurements on landscapes studied but at different locations, or on different landscapes will provide more data for validation and in building up a KL databases to give more accurate estimation of ET in the future.

Key Words: Remote sensing, Flux tower, Evapotranspiration, Crop coefficient, Landscape coefficient.

Inter-annual and seasonal variations in latent heat flux over the mountain cloud forests in northeastern Taiwan

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The Chilan Mountain forest in northeastern Taiwan is a typical subtropical cloud forest. At this site, there is a long-term flux tower ($121^0$25'E, $24^0$35'N) operating continuously since 2006. We monitor variations in hydrometeorological elements, energy flux, and carbon exchange in a Chamaecyparis forest. The annual air temperature ranged from -3.9 ^{0}C to 28.5 ^{0}C and mean annual precipitation was about 4000 mm. There is different source of precipitation in different season. In summer, typhoons are the major source of precipitation; in autumn and winter, the East Asian Monsoon is the main contribution of precipitation. According to the source of precipitation, there is variance hydrological environment in different years and the latent heat flux will be influenced. Beside the source of precipitation, the forest is regularly covered by dense clouds (upslope fog). The local winds bring other source of precipitation and the flux measurement influenced by the dense clouds. The East Asian Monsoon also increase the frequency of fog affecting the flux estimation during autumn and winter. In short, the inter-annual and seasonal variations in latent heat flux over Chilan Mountain forest is dominate by different source of precipitation and East Asian Monsoon.

Keywords: Latent heat flux, cloud forest, fog, upslope fog

Wet use efficiency of a plantation in Da Nong Da Fu, Hualien, Taiwan

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I am planning on measuring the photosynthetic water-use efficiency (WUE) of a plantation in Da Nong Da Fu, Hualien. A CO_2 and H_2O gas analyzer (LICOR-7500a) and a 3D sonic anemometer will be set up on a tower in the middle of the plantation. WUE of photosynthesis is defined as the carbon gain of a plant per unit of water lost from the leaf,s pecifically , transpiration (which is controlled by stomatal conductance). In brief terms, it is the ratio of water loss to carbon gain. A low stomatal conductance of plants in soil water deficit environments results in less photosynthesis but greater carbon gain per unit of water loss by maximizing the diffusion gradient for CO_2 entering the leaf, thus, greater WUE.

Measuring WUE is beneficial when addressing water management issues for agricultural purposes. Apart from DNDF consisting of patches of plantations, it also compromises of crop patches. Knowledge from local farmers mention that, over the years, the water availability has decreased. I will therefore take this issue into scientific terms and try to measure the WUE of the plantation to see if it has a correlation with the crop patches. I also plan, if possible, to compare the plantation's WUE with the area's previous habitat condition, a sugar cane field, from other literatures. I hope to observe if the plantation really does influence the hydrology of DNDF.

A new leaf chamber system for field measurements of photosynthesis and respiration

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Intact leaves' CO_2 fluxes, including photosynthesis and respiration, play a central role in characterizing carbon budget of an ecosystem. There are large number of field measurements of leaf-scale net assimilation (An) rate in the literature, however, a further separation of An into *in situ* photosynthesis and respiration rates is scarce, especially for a prolonged period of time. We therefore designed and built an automatic chamber system for the purpose of field monitoring of leaf CO_2 fluxes. The system is composed of 4 chambers, an infrared gas analyzer, and a control unit. The chambers are equipped with two stages of covers: a transparent one for closing the chamber for measuring net photosynthesis and a dark mask for blocking solar radiation and enabling the measurement of daytime dark respiration. The system was tested on a mature *Zelkova serrata* tree in campus of National Dong Hwa University in Hualien, Taiwan. The two-week dataset showed a convincing performance of that system. We are now improving the sensitivity of CO_2 measurement and will then implement the system into a CO_2 flux measurement network at the Chi-Lan Mountain site, where a long-term study of carbon budget of a cloud forest ecosystem is running with eddy covariance method and chamber techniques in soil, stem, and branch respiration flux measurements.

Oil palm biomass estimation using remote sensing ALOS PALSAR data

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The evaluation of oil palm biomass using remote sensing especially radar data has not been widely carried out. Oil palm biomass contains high economic and environmental value. Thus, the estimation of biomass using remote sensing data is very important for the carbon stock related studies, especially in oil palm plantation. ALOS PALSAR having better penetration ability compared to the optical data were evaluated in this study. The backscatter value of ALOS PALSAR polarization of HH and HV was studied to determine the relationships within the oil palm biomass. Subsequently, the best correlation was identified. The objectives of this study are to estimate the above ground biomass of oil palm trees by age, to investigate the variation of backscatter value corresponding to the oil palm biomass, and to develop empirical models (allometric equations) for oil palm biomass. The above ground biomass of oil palm increases continuously until it reaches a certain growth level (age). Compared to HH, HV polarization gives better correlation with the oil palm biomass. The HV backscattered value showed different correlation as the reflectance value were converted into sigma naught and were filtered. The best correlation was identified to be the HV backscattered value (in decibel) correlation with oil palm biomass, after it was filtered using Lee filter.

Monitoring secondary forest succession in Hong Kong using Remote Sensing and GIS

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Tropical forests are acknowledged for providing important ecosystem services, particularly the carbon sequestration, catchment protection and biodiversity conservation. Knowledge of recovery response and rate of tropical forest to past forms of disturbance may facilitate our understanding on the ecosystem resilience for the present and future events. Latest clear cutting during the Second World War, recovering natural secondary forest, availability of the post war aerial photographs since 1945, and recent high resolution satellite imagery, provide an adequate opportunity to monitor and model tropical vegetation succession in the degraded hills of Hong Kong.

Results of structural changes in habitat indicate that forest cover has increased from 0.17 % in 1945 to ~36 % in 2014. Forest has increased at an annual rate of 7.7 % since 1945, whereas the highest rate of 10.92 % was observed during 1989 to 2001. On the other hand, grassland has decreased with the annual loss of 3.34 %, and the maximum rate of decrease (-12.37 %) was observed during 2001-2014. Increase in mean elevation forest (248 m to 394 m) and grassland (462 m to 649 m) and decrease in proportion of grassland in the landscape (78.62 % to 7.86 %), indicates proportion of later successional stages of vegetation are rising along elevation - as a result, the current grassland habitat is confined to top of the mountains. Analysis of changes in spatial structure of the landscape indicate that succession of forest started with smaller isolated patches and then number of patches and their relative size increased over time. Forest has established rapidly where shrub cover was able to colonise. Therefore, effective forest management policies could include seeding of native shrubs extending linearly from established forest, to maximize edge length between woody species and grasslands, and planting of late successional species in area where forest pioneers are established.

Relationship between crown diameter and tree height of *Acacia crassicarpa* six month aged on lowland area of estate Pelalawan

Dony Julius

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This study purpose is to examine the relationship of the crown diameter and height of trees Acacia crassicarpa age of 6 months, as well as making the model equations. This research was conducted in Estate Pelalawan, Riau.

Data retrieved using systematic random sampling from 30 plot. Data retrieved on circular plot with radius in 10.28 meters (0.04 hectare) and distance between the plot is 100 meters.

Data were analyzed using linear and nonlinear regression approach. Regression models were used linear regression models, logarithmic and quadratic. Crown diameter showed a significant effect on Acacia crassicarpa tree height. The best regression model using the logarithmic regression model with R^2 corrected by 94.1%; RMSE of 0.241; and the deviation of 3.077.

The equation model of logarithmic regression is H=1,8646ln(d)-6,985 , where H = height (m), and d = crown width (cm). This study expected need to be continued for time series of Acacia crassicarpa for delivering accurate measurement of others age, so this study aim for measuring height of tree based on crown width / diameter (forest inventory by aerial photo).

Rice mapping and monitoring in Sylhet region of Bangladesh using MODIS NDVI

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Like many other countries in Asia, rice is the staple food for 160 million people of Bangladesh. On the other hand, rice cultivation has been recognized as one of the major anthropogenic source for CH_4 emissions. Therefore, it is important to know the spatial distribution of rice fields for assessment of food and environmental security. Remote sensing provides the essential technology and methodology to monitor, map, and observe rice-growing ecosystems over large areas, at repeated time intervals. Satellite data from Moderate Resolution Imaging Spectroradiometer (MODIS) is freely available and offers a unique combination of spectral, temporal, and spatial resolution compared to previous global sensors, making it a good candidate for large-scale crop type mapping and monitoring. Therefore, this study was undertaken to identify the area and yield forecasting of rice crop using satellite imagery in the Sylhet region of Bangladesh. In this research, we used Terra and Aqua MODIS-derived 8-day composite of normalized difference vegetation index (NDVI) at 250 m spatial resolution in conjunction with ancillary datasets during the period of 2002-2012. We used ArcGIS 10, ENVI 5.0 and MRT 4.0 to process and analyze these satellite imageries. From this study, the Boro and Aman rice area were found 466194, and 334256 hectares in the Sylhet region in 2012, respectively. The research results showed that Boro and Aman rice area estimated from MODIS data was closely matched with the area reported by Bangladesh Bureau of Statistics (BBS). These remotely sensed Boro and Aman rice area were 14.4% and 11.2% overestimated. Mixed pixel effects might have affected the results. A linear regression model was established based on mean of seasonal average of monthly maximum NDVI and BBS rice production data to predict the future rice production in the Sylhet region. The correlation coefficient (r) between production and maximum NDVI has been found as 0.707 and 0.837 for Boro and Aman rice respectively. The remotely sensed production of Sylhet region was compared with the BBS data during the year 2002-2012. The results show that RS Based Boro and Aman rice production estimation were similar with the production reported by BBS. Therefore, we conclude that our methodology could extensively be used for Boro and Aman rice production estimation with minor improvement and adaptation. Therefore, satellite data of appropriate time frame, coverage & technical specification appeared to be a major concern in effective utilization of remote sensing technology for rice crop mapping and monitoring. Such spatial location map and economic yield map of rice fields can also be used in quantification of carbon emission and identifying alternative options for a greener agriculture. Besides, our research derived rice production models could be used for near real time rice production estimation so that the policymakers could be benefitted for comprehensive decision-making in green agriculture and food policy planning.

Key Words: Remote sensing, paddy rice, yield forecasting, green agriculture

Effects of snowfall on species loss in a temperate steppe in northern China

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The response of species richness to increased snowfall is inconsistent, varying from positive, neutral to negative. A regional-scale transect including 10 snow fence sites was conducted running 500 km across 3 communities in the Inner Mongolia grasslands in order to examine the potential effects of increased snowfall on plant species richness. Our results demonstrated that increased snowfall decreased species richness through strengthen habitat filtering and species competitive interactions. Our findings may have important implications for projection of vegetation dynamics under future global change scenarios.

Straw incorporated after mechanized harvesting of irrigated rice affects net emissions of CH_4 and CO_2 based on eddy covariance measurements

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With the widespread use of combine harvesters in South and Southeast Asia, rice straw remain largely on the field after harvest and are incorporated into the soil during land preparation. The eddy covariance method was employed for the first time to monitor its environmental impacts on the seasonal variations of methane (CH_4) and carbon dioxide (CO_2) emissions from irrigated lowland rice ecosystems over the entire cropping period (encompassing land preparation, growing, and fallow) during the dry (DS) and wet (WS) seasons in 2013 and 2014. The continuous incorporation of rice straw increased both the average and cumulative CH_4 fluxes during land preparation and vegetative growth stage through successive cropping seasons. The cumulative seasonal gross primary production (GPP) and ecosystem respiration (*Re*) as well as the seasonal *Re*/GPP ratio also increased through time, which shows that the amount of CO_2 emissions became higher relative to the CO_2 taken up by the rice plants. This clearly indicates the cumulative effect of residual rice straw from its continuous incorporation in the soil. Results further showed that the annual net ecosystem carbon budget (NECB) for 2013 (984 kg C ha^{-1}) and 2014 (740 kg C ha^{-1}) were both positive, indicating that the irrigated lowland rice ecosystem was a net C sink for both cropping periods. However, it should be noted that the NECB values decreased from 2013 to 2014 due to a decrease in the annual net ecosystem production (NEP) brought about by higher CO_2 emissions and an increase in the annual CH_4 emissions. The annual net greenhouse gas budget (NGHGB) decreased from 348 kg CO_2 eq. ha^{-1} in 2013 to -2052 kg CO_2 eq. ha^{-1} in 2014, indicating that the irrigated lowland rice ecosystem has shifted from being a net GHG sink to a net GHG source due to the increase in annual CH_4 emissions. It should be noted that CH_4 has 25 times higher global warming potential than CO_2 (for a 100-year time horizon). The increasing rate of CH_4 and CO_2 emissions due to continuous rice straw application, such as from combine harvesters, could transform the irrigated lowland rice ecosystem into a net GHG source as well as a net C source. This study, however, showed that leaving rice straw on the surface of the fields after harvest to undergo partial decomposition under aerobic conditions before soil submergence and incorporation during land preparation could provide a management strategy for reducing CH_4 emissions while managing rice straw residues from combine harvesters.

Study of crop-residue return on emission reduction and soil carbon sequestration potential in China

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Crop-residue burning is an important source of gaseous pollutants and particulate matters with significant impacts on global atmospheric chemistry and global climate change, which contributes to the extremely severe and persistent haze pollution suffered by millions of Chinese people. Returning crop residues to cropland instead of burning can simultaneously mitigate emissions and increase soil organic carbon (SOC), which demands further spatially explicit impact assessments. Here we generated the percentage of crop residues burned in the fields and returned into cropland in 7 large regions in China. To calculate the pollutant emissions of crop-residues burning, we used grass valley ratios and emission factors, with the yields of crop residues from different crop species at different burning ratios in different agricultural regions from 2000 to 2010. Results showed that annual emissions of gaseous pollutants and particulate matters were estimated to be 149.89 Tg CO_2, 0.16 Tg NO_x, 0.06 Tg SO_2, 1.23 Tg $PM_{2.5}$ and 0.77 Tg PM_{10} respectively, and North, Central and Northeast China were top three contributors of agricultural regions. Based on EPIC model, which was optimized and validated using the database of long-term observation in Yucheng Station (YCS) and Qianyanzhou Station (QYZ), we stimulated a 10-year spatially explicit topsoil organic carbon density dynamics to estimate SOC sequestration potential of crop-residue return in cropland of China. The enhanced SOC from converting crop-residue burning to crop-residue return was estimated to be 24.46 Tg C yr^{-1}, equivalent to 1.1% of the China's total carbon emission by fossil fuel. The maximum and the minimum increase of topsoil organic carbon density were in dryland of North China and paddy-fields of South China respectively.

Applying differential InSAR method for detecting deformation of Merapi volcano eruption in 2010

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Mount Merapi is one of volcano in the world that have high importance to be researched. It is caused by the volcano location adjacent with human civilization that can be dangerous if the volcano erupt or other activity occurs. Therefore mount Merapi observation is needed to reduce hazard caused by disaster. The deformation observation can be done with InSAR (Interferometric Synthetic Aperture Radar) method.
InSAR is one of methods to understanding deformation that used in some volcano deformation research. With this method there is using of fase differential from two SAR satellite image thus make interferogram that has topography of Earth, curvature of Earth, deformation, noise, atmosphere effect and orbit effect information. Deformation information can be obtained by reducing all of information in the interferogram except deformation information. Global DEM SRTM 3” is used in this researched to reduce topography effect with some series of DInSAR process. In this research, interferogram made from some pair of ALOS PALSAR to make DEM with better resolution than Global DEM SRTM 3”. This data would be used as comparison in DInSAR process. Result of comparison indicate that deformation map that obtained by using DEM made from SAR and Global DEM SRTM 3” has same deformation pattern but has different resolution and accuracy. Also from this research, there was inflation that occurs in Mount Merapi before eruption and after eruption, inflation still occurred on Mount Merapi with lower activity than inflation before eruption.

Key word : InSAR, Deformation, DEM, Volcano, Merapi

Linking AsiaFlux data and GOSAT observation for terrestrial CO_2 cycle studies

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We will present our experiences of application of GOSAT observation data and network of eddy-covariance observation data (e.g. AsiaFlux) to understand terrestrial carbon fluxes at continental to global scales. Possible observed parameters from GOSAT observation to link eddy-covariance are sun-induced chlorophyll fluorescence (SIF), column CO_2 concentration, and inversely estimated net land-atmosphere CO_2 fluxes. Among them, we have been working on application of SIF and inversely estimated net CO_2 fluxes.

Differences of spatial scales between GOSAT observation and eddy-covariance measurement are one of the difficulties to link them. To fill this gap, we applied empirical upscaling (data-driven model) using network of eddy-covariance data and remote sensing data to create spatial maps of terrestrial carbon fluxes (Yang et al. 2007; Ichii et al. 2010; Saigusa et al. 2010; Ueyama et al. 2013; Kondo et al. 2015). We generated terrestrial CO_2 fluxes (GPP and NEE) at global (Kondo et al. 2015) and Asia (Saigusa et al. 2010) with version 0.25 degree and 8-days interval. FLUENET fair-use data and AsiaFlux data were used to create global and Asia products, respectively.

We found good consistency between SIF (from GOME-2 satellite) and data-driven GPP for seasonal and interannual variations for temperate and boreal regions. We found large discrepancy between them in south Asia regions, where eddy-covariance observation data is lacking for our model. In addition, net CO_2 fluxes of data-driven and GOSAT estimations at seasonal and interannual variations show consistency in temperate and boreal regions with large differences in tropical regions (Kondo et al. 2015). Magnitude of land-atmosphere net CO_2 budget show large discrepancies especially in tropics.

In summary, empirical upscaling using eddy-covariance network data is an essential step to link eddy-covariance observations and GOSAT observations. Our initial evaluation revealed that data-driven GPP is reasonably estimated, and data-driven NEE and GOSAT-based net CO_2 flux needs further refinements.

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Estimations of 1km grid Global Terrestrial Carbon fluxes using the diagnostic biosphere model

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Estimating global terrestrial carbon fluxes with high accuracy is important to understand global environmental changes. Additionally the estimations with 1km grid resolution may contribute to policy makers and other social activities. In order to reveal the present state of terrestrial carbon fluxes covering a wide range and a decadal scale, using the satellite-based diagnostic biosphere model is suitable because of uniformly observing on the earth. But the diagnostic model can use only a few decades of data, and have the potential to underestimate the annual carbon fluxes as a result of doing spin-up to the steady state. In this study, we optimized the spin-up time of the terrestrial biosphere model (BEAMS) in each sub continental region using estimations of carbon fluxes by the atmospheric transport model (GOSAT L4A global CO_2 flux), and then estimated the 1km grid global terrestrial carbon fluxes. Significant improvement of the estimation accuracy was achieved by using the two satellite data (GOSAT as atmospheric information, and MODIS as land surface information). Annual net carbon fluxes were indicated similar values between BEAMS, GOSAT L4A, and GCP estimations, and perhaps these may be reasonable. In a tropical regions that are low satellite observation data, the accuracy of carbon fluxes remained a matter of discussion. Future work is that more optimizations of BEAMS flux in order to be moderately changing around GOSAT L4A boundary.