



March 2007  
Issue No.21

## AsiaFlux Newsletter

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### Report on the FLUXNET Synthesis Workshop 2007

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#### Outline of the workshop

**F**LUXNET Synthesis Workshop 2007, together with GTOS-TCO (Global Terrestrial Observing System-Terrestrial Carbon Observations), was held from 18 to 22 February in La Thuile, Italy that is well known by its fine ski resorts on the foot of Mt. Mont Blanc, with many (ca. 60) leading scientists in the flux studies from all over the world (Photo 1 and 2). Two scientists from JapanFlux, two from ChinaFLUX and USCCC (US-China Carbon Consortium), and one from KoFlux took part in the workshop from Asia region. D. Papale and M. Reichstein took the chair of the plenary sessions throughout the

workshop.

The workshop was sponsored by University of Tuscia – Viterbo (Italy), Max-Planck-Institute for Biogeochemistry–Jena (Germany), US Department of Energy, The National Science Foundation (USA), iLEAPS (Integrated Land Ecosystem - Atmosphere Processes study) of IGBP, GTOS-TCO and FAO (Food and Agriculture Organization of the United Nations), and organized with the aim, 1) to do synthesis activities using the global standardized eddy flux dataset available, and 2) to build a strong partnership with other flux networks in the world such as AsiaFlux, ChinaFLUX, KoFlux, AfriFlux, LBA and so on. For this reason,



Photo 1 Commemorative picture



Photo 2. Workshop poster



Photo 3. Plenary session

there was no presentation scheduled (just few to introduce the topics and describe the dataset) but parallel sessions where groups of 10-15 people could really work on the data. Participants were separated into 4 parallel sessions in 3 time slots (everyone can contribute to at least three scientific issues then). At least 6.5 hours of discussion time were allocated for each session, and additionally long lunch break (4 h) and dinnertime were used for the further discussion on the synthesis papers and related subjects (Participants also could ski during this lunch break, if they wished). Outcomes from each

session and plans for synthesis papers were reported and discussed at the final plenary session on the last day (Photo 3). Moreover, committee proposed four global synthesis topics at the final plenary session, and their contents and leading authors were discussed.

Preceded to the workshop, organizing committee had asked the principle investigators (P.I.s) of the flux sites in the world to submit the half-hourly flux data, in order to make the global standardized database (the dead line was 15 November, 2006). Table 1. shows the list of variables required for the submission. All the flux data had been quality controlled (Papale *et al.*, 2006) and  $u^*$  filtered (Reichstein *et al.*, 2005; Papale *et al.*, 2006), and gap-filled, partitioned and aggregated (Papale and Valentini, 2003; Reichstein *et al.*, 2005), using standard algorithms. Minimum Distance Sampling gap-filling and flux-partitioning were also available online at (<http://gaia.agraria.unitus.it/database/eddyproc>). 619 sites\*years of flux and micrometeorology data from 31 countries and 180 sites had already been submitted including 8 sites\*years data from AsiaFlux and 14 sites\*years data from ChinaFlux and USCCC (Figure 1). Although some synthesis works have already started, the organizing committee still encourages additional data submission (especially for Asia region) until 15 April 2007, as stated in the last sentences of this report. They really hope, so please contribute actively to FLUXNET with your data on this occasion. They might contact AsiaFlux about your data or their latest news, so when you submit your data, please inform AsiaFlux secretariat ([secretary@asiaflux.net](mailto:secretary@asiaflux.net)) about it.

### Global synthesis proposal and reports from each session

Key features and issues of the global synthesis session and other sessions were as follows. A mailing list and/or a web page will be created for each group, in order to continue further discussion within each group. Several synthesis papers will be submitted to different journals regarding these issues.

#### A. Global Synthesis (R. Valentini, Italy)

1. Global distribution of GPP, NEE, RE  
Goal: To produce a reference paper on the FLUXNET 2007.

Probability distribution functions; Robustness of the GPP-RE relations; NEE increase with



**Table 1. List of variables (30 min. int.) required for FLUXNET synthesis (ver. 1.0).**

**Variables mandatory**

These variables are all mandatory.  
If one of these variables is missing, the dataset will not be processed at all.

Variable	Abbreviation	Unit	Comment
Decimal day of the year	DTIME		
CO <sub>2</sub> flux	FC	micro. mol m <sup>-2</sup> s <sup>-1</sup>	not storage corrected, not ustar filtered and not gapfilled
CO <sub>2</sub> concentration top of the tower and/or storage flux	CO2_top/ SFC	ppm/micro. mol m <sup>-2</sup> s <sup>-1</sup>	
Ustar	UST	m s <sup>-1</sup>	or Momentum (tau)
Global incoming radiation or PPFD	RG_in/ PAR_in	W m <sup>-2</sup> /micro. mol m <sup>-2</sup> s <sup>-1</sup>	
Air temperature	TA	deg. C	
Water vapour concentration and/or Relative humidity	H2O/RH	mmol mol <sup>-1</sup> / % [0-100]	

**Variables very important**

These variables are indispensable for part of the papers planned and if submitted (also part of these) the site will be involved in more papers. For this reason we strongly suggest to submit also these variables.

Variable	Abbreviation	Unit	Comment
Latent heat flux	LE	W m <sup>-2</sup>	
Sensible heat flux	H	W m <sup>-2</sup>	
Soil heat flux	G1	W m <sup>-2</sup>	
Water vapour concentration	H2O	mmol mol <sup>-1</sup>	
Relative humidity	RH	% [0-100]	
Precipitation	PRECIP	mm	
Soil water content	SWC	% [0-100]	also more than one depth
Soil temperature	TS	deg. C	also more than one depth
Reflected radiation	RR	W m <sup>-2</sup>	
Net radiation	RNET	W m <sup>-2</sup>	
Diffuse radiation	RD	W m <sup>-2</sup>	
Absorbed PAR or Fraction of PAR absorbed	APAR/ FAPAR	micro. mol m <sup>-2</sup> s <sup>-1</sup> / % [0-100]	
Wind direction	WD	degrees	
Wind horizontal speed	WS	m s <sup>-1</sup>	
Air pressure	PA	kPa	
Atmosphere stability parameter	ZL		

**Ancillary information required (mandatory)**

- Site name
- PI name and email
- Geographic coordinates (latitude longitude, WGS84, first decimal of second precision (e.g. 44° 27' 52.3"))
- Measurement height
- Land cover and Land use

**Ancillary information important**

- Management
- LAI
- Biomass
- Age
- etc



## 619 years of data from 180 sites

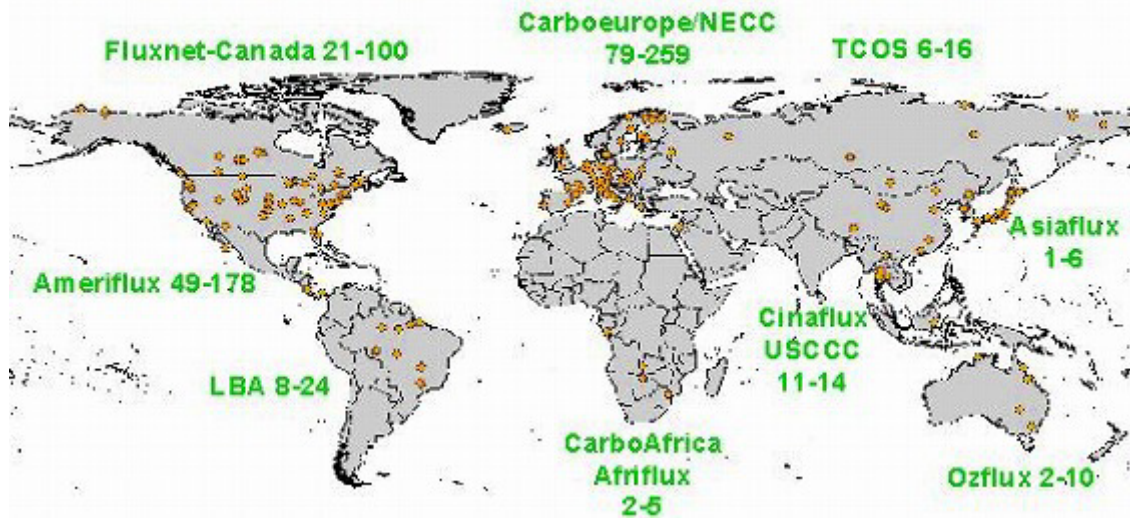


Figure 1. Numbers of sites (left) and sites\*years (right), from which flux data were submitted.

GPP?; Maximum biophysical GPP and its deviation with biome types.

2. A new global map of NEE and relations with GPP and RE using data driven models

Goal: To provide a FLUXNET “view” of distribution of NEE to compare with existing global models.

Artificial neural networks, Multiple regression, RUE based models; Compare regional estimates with inversion; Disturbances; Driving factors.

3. Inter-annual variability and climate sensitivity

Goal: Global characterization of inter-annual variability and driving factors and processes. Integration of FLUXNET data signals with global modeling and atmospheric inversion estimations; Inter-annual variability versus spatial variability (for different biomes).

4. Surprises from FLUXNET

Goal: What emerging processes we see in data analyses that are not captured by existing global models.

Comparison of FLUXNET data with global model responses; Diffuse/direct light responses; Spring onset of photosynthesis; Water/carbon relations for respiration; Pulses and switches.

### **B. Boreal Synthesis (H. Margolis, Canada)**

Circumpolar boreal systems; Seasonal patterns-commonalities and differences including analysis of major parameters at 30 min., daily, monthly time steps; Inter-annual

flux variability and environmental factors; Boreal light use efficiency and its potential for analysis by remote sensing.

### **C. Temperate Synthesis (N. Buchmann, Switzerland)**

Clearing of data → 101 sites and 364 sites\*years in temperate zone; How different are seasonal (inter-annual) patterns within the same latitude across ecotypes? (Search for common patterns for global model); Where can MODIS observe these patterns? Where not, Why; What drivers determine the length of the growing season within the climate space?

### **D. Seasonally droughted (Mediterranean and sub-tropic) Synthesis and Rain Pulse (F. Miglietta, Italy)**

Characterization of seasonal pattern of carbon and water flux in seasonally droughted ecosystem; Influence of water availability on carbon gain (GPP) and loss (RE) on seasonally droughted ecosystem; Influence of climate, soil and vegetation on rain pulse responses in seasonally droughted ecosystems (across different ecosystems); How variability in rainfall frequency, magnitude and duration affect GPP and RE in seasonally droughted ecosystems; Estimation of parameters controlling canopy responses in droughted ecosystems via SVAT model inversions.

### **E. Tropical Synthesis (Y. Malhi, U.K.)**

Tropical systems are largely limited by



either water or light (unique, in many ways, but also overlap with Mediterranean ecosystems?); Explore water and radiation limitations across the gradient of flux sites; How similar or different are wet rainforests across the tropics?; Compare seasonal/mixed tree-grass sites (including some temperate sites); What can the flux data tell us about the differences between tropical forest and tropical grassland? - Preliminary analysis shows max GPP to be very similar.

#### **F. GPP-RE-NEE**

Evaluation of current 'GPP' estimates (Does temperature dependence hold into day?, Use of light response curve to estimate GPP); Limitations on GPP (max. RUE annual scale); Factors influencing between site and temporal variability of RE; Lags between GPP and RE comparing daily values aggregated to 8 days (Should we expect NEE lags GPP on daily basis?); Evaluate model predictions.

#### **G. Management/Disturbance/N (J. Grace, U.K.)**

Carbon fluxes associated with disturbances-towards a generalized model; Forest disturbances, based on chrono-sequences, clear-cuts and canopy thinning; Make recommendations for the management of ecosystems as C accumulators (Old forests, Stats. on disturbances, Remote sensing data and disturbances).

#### **H. Lag-effects of extreme events (P. Stoy, U.K.)**

Monthly anomalies of ecosystem CO<sub>2</sub> and H<sub>2</sub>O exchange; Are ecosystem responses to anomalies consistent by eco-climatic domain?; Time scale analysis of persistence; Space-time coherence of climate and flux; Are FLUXNET data spatially coherent? in phase?; Short-term extreme drivers and responses; What are the characteristic and importance of short-term extremes (temp., prec., wind,...) across ecosystems?; Process-based hypothesis testing would be a) identifying pulses and ecosystem responses, b) need to define extreme, c) characteristics, magnitude, lag, time structure, d) is there a threshold of response?, e) role of initial conditions?

#### **I. Energy-Partitioning, Bowen-Ratio, Water flux and WUE**

Uncertainty of transpiration/evapotranspiration by eddy technique? → Basis for later WUE analysis; Ancillary data, such as

sap-flow measurements are critical; Bowen ratio analysis during heat wave 2003 in Europe; Energy partitioning and Bowen ratio analysis across global climate regions and ecosystem types; Water flux partitioning of different ecosystem types; Ecohydrological hypotheses (Budyko); Coupling of carbon and water fluxes via canopy conductance. Water limitation of canopy conductance, Which hydrological property/ratio relates best to GPP? (soil hydrology, timing of precip.); Interpretation of diurnal courses of carbon and water fluxes (Decrease in A/g in the afternoon); Testing optimal stomatal control hypothesis; Energy partitioning and water flux partitioning; How does the water flux and WUE change after disturbance or with land-use?; How about dew in the morning?; Density dependence on evaporation.

#### **J. Direct/Diffuse radiation and RUE**

Availability of Dir/Dif PAR data at the FLUXNET sites-> 30 sites and 73 sites\*years of data available; Availability of long term series of diffuse global radiation, call for data; Model simulations with CANVEG shows no differences in fPAR and a difference in GPP of 50 gC year<sup>-1</sup> for 10% variation in diffuse PAR; Proposed methodology to retrieve structural/physiological parameters; Sensitivity of GPP and NEP to direct vs diffuse radiations across FLUXNET sites; How biomes have responded to global variations in incoming radiation; Effect of land use change and global warming on winter albedo; Testing and improving models for the separation of PAR radiation in direct and diffuse component; The canopy structure information content of flux measurements; Albedo variation in time and space; Validation of MODIS albedo.

#### **K. Model parameter estimation (R. Leuning, Australia)**

Most GCMs use Look Up Tables to assign parameter values for various plant functional types (PFT); However, there is little variation in parameter values within PFT; Use the FLUXNET dataset to estimate parameters of several SVAT models used in GCMs, using non-linear parameter optimization techniques to representative flux tower data for each PFT; Look at distribution of parameter values for each PFT to determine ranges and means; Compare values from model inversion with default values used in current GCMs; Run



models, in forward direction to examine consequence of mean and standard deviations of model parameters on calculated fluxes of CO<sub>2</sub>, water vapor and heat.

#### **Database, paper evolution procedure, data sharing policy and co-authorship**

To check hypotheses derived from each session discussion, organizing committee had intended to use a synthesized database during this workshop which is developed by Microsoft® and contains all the flux and micrometeorology data (they called this database “Data Cube”). The Data Cube can extract and show a dataset as user’s demand. However, the “Data Cube” was not available yet with its complete functions, and engineers from Microsoft® were continuously working on the “Data Cube” during the workshop. Therefore, processed flux data only as ASCII text files were given to participants to check whether the FLUXNET data support the participant’s hypotheses or not. At the end of the workshop, engineers showed a brief outputs generated from the “Data Cube”, so the complete database will be available soon.

In the final plenary session on the last day, the organizing committee proposed policies for data sharing and co-authorship and there were many opinions from participants regarding these issues. Some participants concerned about the huge numbers of co-authors. The organizing committee proposed an alternative policy after the workshop with reference to the opinions from participants, however a part of these policies are still under debate. The proposed policies by committee were as follows,

#### **a) Paper evolution procedure**

1. Have a compelling multi-site synthesis idea
2. Paper title and short outline (what do you want to look at and how) and CV of initial coordinator communicated to SC (a committee).
3. SC will:
  - i. check for overlaps and synergies
  - ii. submit application to use data to regional network coordinator (paper outline and CV of lead author)
  - iii. post on the webpage topic, outline and contact and inform and invite all data providers (flux data and also spatial data) to give input and participate
4. Scientific communication will be then

between lead authors and co-authors.

#### **b) Authorship and acknowledgement policy**

- i. All the data providers are invited to give intellectual input
- ii. Intellectual input should lead to co-authorship, data contribution to group co-authorship if possible with journal (cf. Rustad *et al.*, TERRAC meta-analysis)
- iii. Final decision is with lead author
- iv. Topic is assigned to group for one year (after that deadline topic is open for alternative analysis)
- v. Appropriate acknowledgement required of funding agencies for data and workshop (e.g. iLEAPS, TCO), regional networks

#### **c) Data sharing policy**

Until May 2008, only data contributors are eligible to use data, only in the context of the FLUXNET synthesis papers. Under no circumstances data may be circulated to non-participants in the FLUXNET synthesis activities because of conditional agreements with different networks.

#### **d) Data contribution**

All data contributors are contacted immediately about their current and potential data contribution. Until 15 April 2007, micrometeorological and meteorological data can be added or withdrawn. If no response is received agreement with the status quo is assumed. After this date, the final FLUXNET synthesis database will be released. A new version of the database will be released after one year.

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## Science Topic “Measurement of Isoprene in a Temperate Deciduous Forest in Japan”

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### Introduction

Terpenoids are biogenic volatile organic compounds (BVOCs) emitted by many plant species. Especially isoprene is the most abundant hydrocarbon and the emission is estimated to be 506Tg/year (Guenther *et al.*, 1995). Terpenoid emission contributes to the reactive carbon budget entering the troposphere. Because of their high reactivities, terpenoid emission is a major factor in controlling the concentrations of ozone and other secondary pollutants in the lower atmosphere and increase the lifetime of greenhouse gases such as methane. In Japan efforts to measure and understand the mechanism controlling BVOC emissions and to establish their emission inventories for the country have not been performed extensively.

### Measurement of isoprene emission from vegetations

Here, we show the method how we use a LI-6400 portable photosynthesis system (Li-Cor Inc., Lincoln, NE, USA) for the measuring of isoprene emission. This method can measure rates of isoprene emission and net assimilation simultaneously. Thus, this method has been often used for the measurement of isoprene emission from vegetation (e.g., Tani *et al.*, 2006; Pegoraro *et al.*, 2004). For measurements of isoprene emission, an air sample is pumped out of the outlet of the LI-6400 leaf cuvette through a ‘T’ junction (Fig. 1). Isoprene was trapped by adsorbents (Tenax 200mg and Carbotrap 100mg) packed into stainless steel tubes (Perkin Elmer) and the

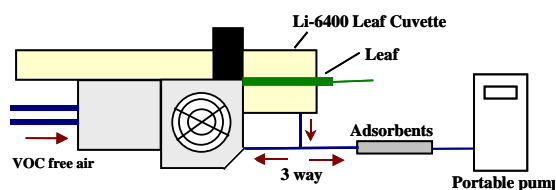


Fig. 1 Isoprene sampling using the portable photosynthesis system

samples were stored at  $<5^{\circ}\text{C}$  until analysis. A GC-MS system (Shimadzu QP5050A) was used to analyze isoprene of the samples undergoing two stage thermal desorption (Perkin-Elmer ATD) (Tani *et al.*, 2002).

### Field experiments and Results

We have conducted the field experiments on isoprene emission from *Quercus serrata* which is one of the major tree species in Japan. The measurement site was a temperate broad-leaved secondary forest, Yamashiro, Kyoto ( $34^{\circ}47'\text{N}$ ,  $135^{\circ}50'\text{E}$ , Fig. 2). Rates of isoprene emission and net assimilation, photosynthetic photon flux density, air and leaf temperatures were measured on June, July, August and October 2006 using a LI-6400 portable photosynthesis system. Several Leaves of a 12m-high tree were used for isoprene sampling.

Obvious effects of PPFD and leaf temperature on isoprene emission were observed (Fig. 3). Emission rate of isoprene was highly correlated with leaf temperature. Isoprene emission reached the peak around noon for both sunlit and shaded leaves. While in the case of net assimilation rate, sunlit leaves had their peak in the morning followed by gradual decrease (Fig. 4). We calculated ratio of carbon emitted as isoprene to carbon fixed by photosynthesis (*Carbon ratio*). The highest isoprene emission rate and *Carbon ratio* was observed at sunlit leaves in August ( $141\text{ nmol m}^{-2}\text{ s}^{-1}$ , carbon ratio: 6.5%).

### Acknowledgments

The authors are grateful to Dr. Yuji Kominami and Dr. Takafumi Miyama for assistance with experiments. Thanks also to Associate Professor Susumu Tohno, Associate professor Yoshiko Kosugi and Dr. Satoshi Takanashi for helpful suggestions. This study was supported in part by funds from Kyoto University 21COE Program “Establishment of COE on Sustainable Energy System”. If you feel interested in our issue or others, please



Fig.2 Location of Yamashiro.



Photo 1 View of the Yamashiro site.



Photo 2 *Quercus Serrata*



Photo 3 View of measurement system.

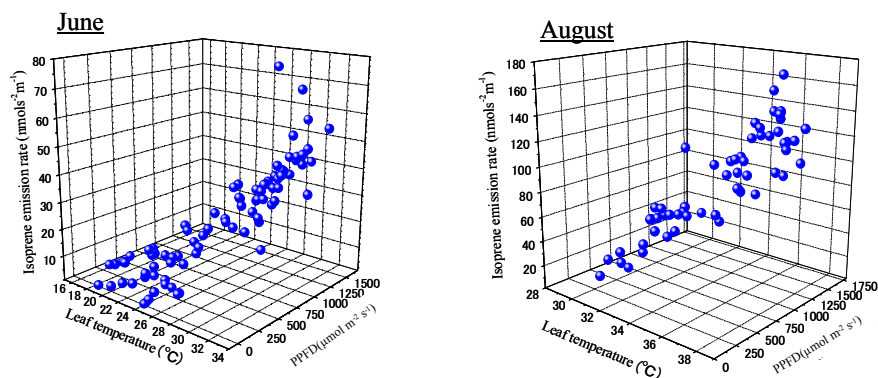


Fig.3 Isoprene emission as a function of PPFD and leaf temperature.

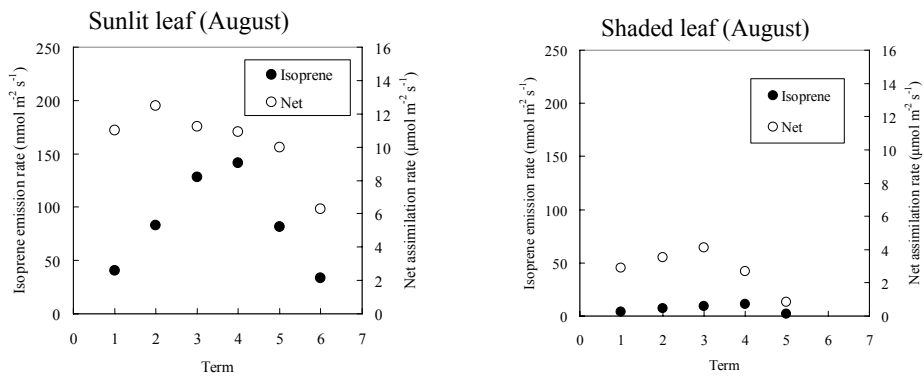


Fig. 4 Temporal variations in rates of isoprene emission and net assimilation of sunlit and shaded leaves. Sampling term (1: 7:00-9:00, 2: 9:00-11:00, 3: 11:00-13:00, 4: 13:00-15:00, 5: 15:00-17:00, 6: 17:00-18:30), number of samples: 4-6 leaves.





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## Phenological Eyes Network (PEN) --- A Validation Network for Remote Sensing of the Terrestrial Ecosystems

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### 1. Introduction

Satellite remote sensing (RS) is regarded as a strong methodology in the study of terrestrial ecosystems. For example, RS is used in scaling up of the ground measurements of carbon flux, water flux, biomass, etc. from a site scale to a regional or global scale. RS provides numerical regional ecological models with information for initial conditions, boundary conditions, and validation. For the sake of it, various new satellite sensors have been designed and launched recently. They are now delivering a lot of high-level products regarding to the terrestrial ecology, such as new vegetation indices, LAI, FPAR, phenology, GPP, and NPP.

However, in the ecological standpoint, these RS methodology has not enough checked or validated on the ground level. Because an essential characteristics of an ecosystem is its dynamism (especially the seasonal change, or "phenology"), the accuracy, quality, and interpretation of the RS data should be also studied dynamically. For the sake of it, a stable, continuous, long-term, and multi-ecosystem ground validation network is desired. Of course, the flux observation networks such as AsiaFlux have potential to contribute to it. However, because RS observes vegetation's optical

characteristics rather than carbon or heat flux, we need to include optical (spectral) observation in the validation of ecological RS. We believe that the ecological interpretation of RS data is possible only if it is based on a careful theoretical and experimental study of the relationships between optical characteristics and ecological structure (or function), using the quality-controlled RS data considering the relevant noise factors such as cloud contamination or atmospheric aerosols.

With this background stated above, we have started the "Phenological Eyes Network (PEN; Tsuchida *et al.*, 2005)." PEN is a network of ground observatories for long-term automatic observation of the vegetation dynamics (phenology), vegetation's optical properties (such as spectral reflectance), and the atmospheric optical properties (such as aerosol optical thickness). Most PEN ground sites have been set up at the AsiaFlux sites. The collaboration of PEN and AsiaFlux is critically important in the interpretation of the optical signals captured by RS in terms of ecology (especially the terrestrial carbon/water cycles).

### 2. Observation system

Fig. 1 is an illustration of a typical system in a PEN site. Because the goal of PEN is to collect long-term quality-controlled multi-site

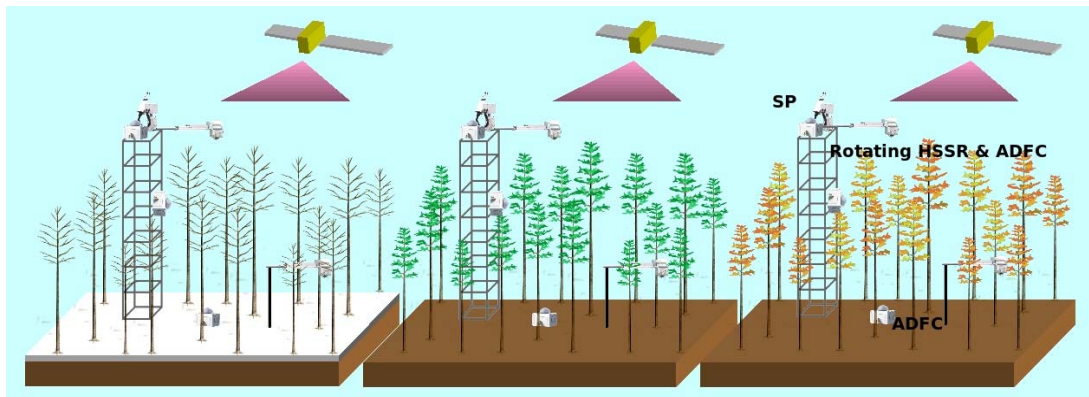


Fig. 1 Illustration of PEN's observation framework.

SP: sunphotometer; ADFC: automatic digital fisheye camera; HSSR: hemispherical spectral radiometer.



Fig. 2 ADFC (Takayama site).



Fig. 3 HSSR mounted on the rotating stage (Takayama site).



Fig. 4 Sunphotometer (Takayama site).



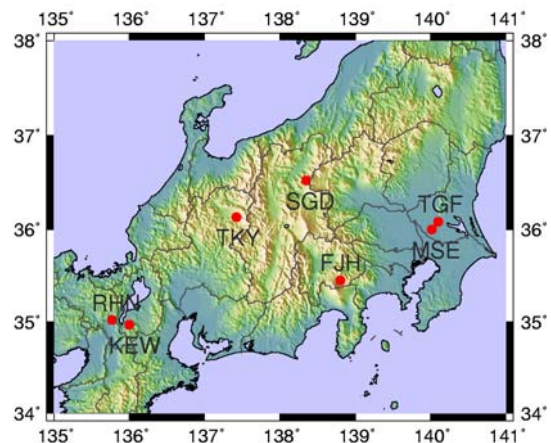
data, the main instruments should be stable, robust, and low-cost. Based on this principle, we selected and designed the following three types of instruments: the Automatic-capturing Digital Fisheye Camera (ADFC), the HemiSpherical Spectro-Radiometer (HSSR), and the sunphotometer (SP).

ADFC (Fig. 2) is a combination of a high-quality digital camera (Nikon CoolPix series), a fish-eye lens (Nikon FC-E8), a water-proof housing case, and a control system with a personal computer. It captures images of the sky, the canopy from above and below, the forest floor, and shoots of typical species with short intervals (2 minutes to 24 hours, depending on the target). These images provides information about cloud condition at the satellite's observation, vegetation phenology, snow pack, tree cover, and LAI.

HSSR (Fig. 3) is a hyper-spectral radiometer in the visible and near-infrared region (MS-700 of Eko Instruments Co. or PGP-100 of Prede Co.). In order to catch both incoming and reflecting radiation with a single radiometer, we developed a computer-controlled rotating stage in collaboration with Hayasaka Rikoh Co. If the HSSR is mounted on the rotating stage, it can be directed upward and downward consecutively with a short interval of time at a same position. Thus we can obtain the spectral features of the vegetation canopy with fine-temporal and fine-spectral resolution. By using such data, we can check the spectral observation of RS. Moreover, we can simulate various types of spectral indices (such as NDVI, EVI, PRI) with arbitrary spectral response of every specific satellite sensors.

SP (Fig. 4) is a spectral radiometer with a small field-of-view and pointing functionality. We use POM-02 of Prede Co. We can estimate optical properties of the atmosphere which are needed for atmospheric correction of the RS data. It can provide quantitative information about atmospheric pollution or aerosol dust (such as the Yellow Sands), both of which may have some direct or indirect impacts on the ecosystems.

In addition to the above-mentioned main instruments, in some sites, we are making observation of environmental ecophysiological properties including incoming PAR (direct and diffuse), transmitting PAR, leaf phenology, LAI (LAI-2000, fisheye image, laser profiler,



**Fig. 5** PEN sites in the central Japan. TGF: TERC Grass Field in Univ. Tsukuba; MSE: Mase paddy site (NIAES); SGD: Sugadaira grassland (Univ. Tsukuba and Tamagawa Univ.); TKY: Takayama forest site (Gifu Univ. and AIST); KEW: Kiryu Experimental Watershed (conifer forest; Kyoto Univ.)

and litter trap), leaf-level optics, leaf-level physiology (LI-6400, pigments, C/N, LMA).

### 3. Observatories and database

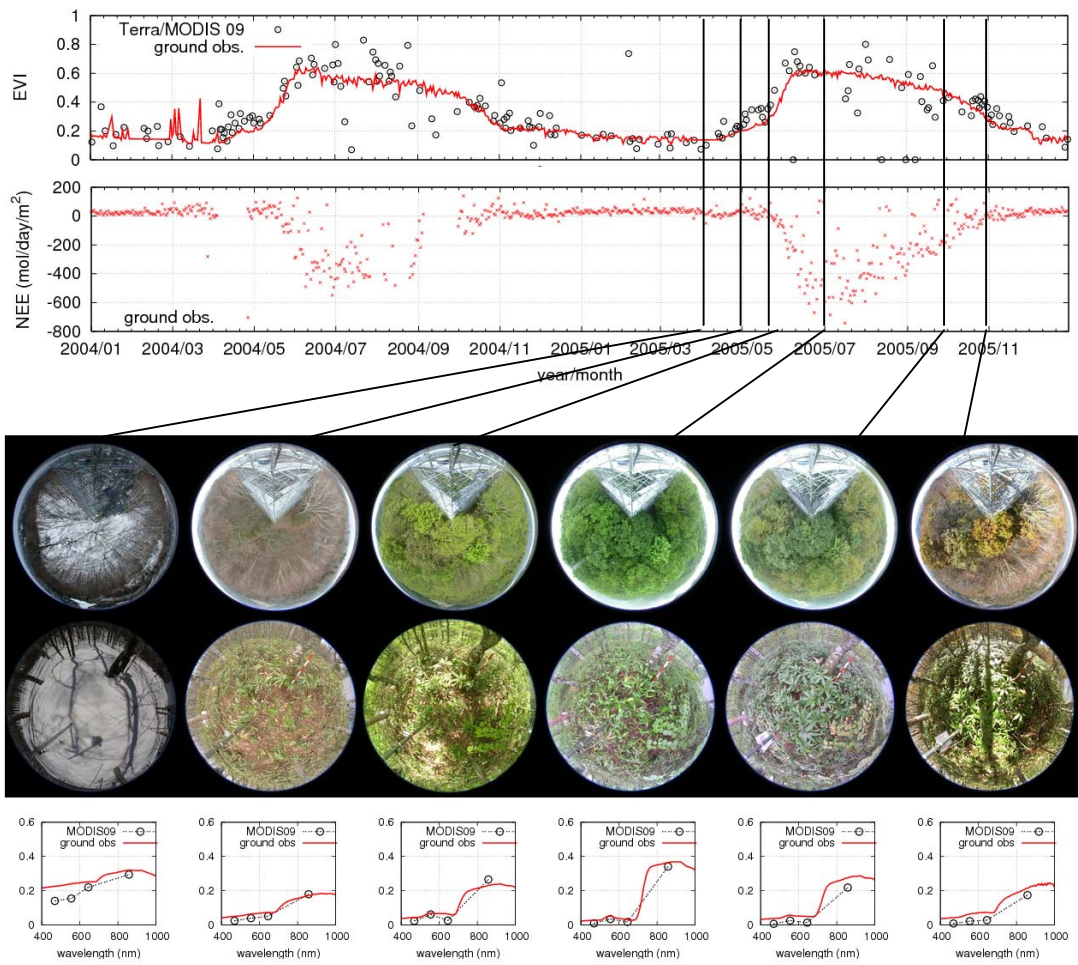
Fig. 5 shows location of some PEN sites in the central island of Japan. In addition to them, PEN includes the Tomakomai site in Hokkaido (destroyed by typhoon hit in 2004) and some site network run by Dr. Minoru GAMO's group in AIST (3 sites in the south-east Asia and one in Japan). In addition, a new site is scheduled to establish by Kochi University in the Shikoku Island.

Most data taken by these sites have been stored in the PEN's database server. The original data are open to the PEN community member (anybody can join if they want) and the summary or edited data are open to the public. If you are interested in the PEN data or PEN's activity, please visit the following website and contact us: [www.pheno-eye.org](http://www.pheno-eye.org)

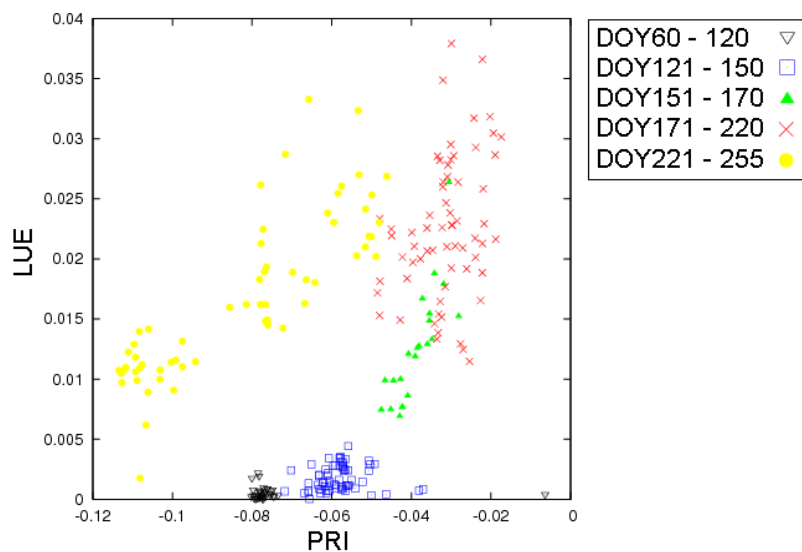
### 4. Example of the observed data

Fig. 6 shows comparisons of satellite, PEN, and eddy flux in the Gifu University's Takayama site (cool-temperate deciduous broad-leaf forest). Although the spectral index (EVI: Enhanced Vegetation Index) showed consistent seasonal change with the carbon flux on the ground level, the satellite-observed EVI showed fairly noisy and unstable changes even after quality control against atmospheric noise as well as cloud contamination.

Fig. 7 shows relationship between PRI (Photochemical Reflectance Index) and LUE



**Fig. 6** Seasonal changes of Takayama forest site captured by RS, PEN, and eddy flux measurements. Top: EVI (Enhanced Vegetation Index) captured on the ground by HSSR of PEN and NEE (Net Ecosystem Exchange) captured by the eddy flux measurement. Middle: ADFC images of the canopy surface and the forest floor. Bottom: the canopy spectral reflectance observed by HSSR and satellite (Terra/MODIS).



**Fig. 7** Photochemical Reflectance Index (PRI) and Light Use Efficiency (LUE) at the Mase paddy site taken in 2005. Courtesy: Takeshi Motohka.



(Light Use Efficiency; ratio of GPP and PAR) observed in the Mase paddy site of NIAES. We can simulate and test such vegetation index on the ground level and study its utility before designing the future space sensor for it.

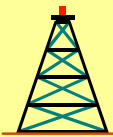
### 5. Discussion and conclusion

Because most of the earth-observing satellites live less than ten years, we need to connect data taken by multiple satellites if we study the temporal changes of the ecosystems for more than ten years. It is PEN's another mission to contribute to such long-term analysis by giving the continuous long-term ground reference data for bridging the multiple satellites. We would like to ask the AsiaFlux communities for their continuous and mutual cooperation with us.

### Acknowledgment

Flux data in Fig. 6 and Fig. 7 were provided by Dr. Nobuko SAIGUSA in AIST and Dr. Akira MIYATA in NIAES. The data in Fig. 5 are taken in cooperation with the Gifu University's COE21 program. PEN's activity and outcomes are mostly the results of contributions of many PEN members including Drs. Satoshi TSUCHIDA and Akihide KAMEI in AIST, Drs. Hiroyuki OGUMA and Koki IWAO in NIES, Takeshi MOTOHKA and Takafumi IKEDA in Univ. of Tsukuba, and the AsiaFlux members in the each PEN site. PEN has been supported by the Global Environment Research Fund (S-1: Integrated Study for Terrestrial Carbon Management of Asia in the 21st Century Based on Scientific Advancement) of the Ministry of Environment of Japan.

*Site Info*



## Introduction To The Flux Measurements over a Gmelin Larch Forest in Tura, Central Siberia, Russia.

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### Introduction

This article introduces flux measurements at a larch forest in Tura, central Siberia. Larch forests consisting of three major species (*Larix sibirica*, *L. gmelinii* and *L. cajanderi*) are widely distributed in Siberia. These forests comprise more than half of the Siberian boreal forests and about 40% of all forested areas in Russia (Abaimov *et al.*, 1998). In particular, two larch species (*L. gmelinii* and *L. cajanderi*) are distributed predominantly in continuous permafrost regions of central and eastern Siberia, respectively (Fig.1). However, there are only a few series of continuous micro-meteorological measurements on fluxes of water vapor, carbon dioxide and other trace gases in the larch ecosystem in Siberia, in spite of its potentially large carbon stock over the vast area. Thus, there is limited information on annual and seasonal variations in NEE (Net ecosystem exchange of carbon dioxide) in larch forest ecosystems with a typical stand structure.

*Larix gmelinii* (Gmelin larch) dominates the immense continuous-permafrost region of the Central Siberian Plateau (Fig.1). Over the last decades, intensive field studies have been conducted in *L. gmelinii* forests of central Siberia, under a joint Russian–Japanese research project, regarding tree growth and stand dynamics (Abaimov *et al.*, 2000; Zyryanova *et al.*, 2000; Osawa *et al.*, 2004), biomass accumulation (Kajimoto *et al.*, 1999, 2003), and soil carbon and nutrients (Matsuura and Abaimov, 2000; Matsuura *et al.*, 2005).

In conjunction with these ecological studies, in 2002 we selected a typical mature stand of Gmelin larch forest near the town of Tura (Fig.2) for micro-meteorological measurements. In 2003 the Russian colleagues in Tura constructed a wooden tower (with the main pillars and framework made from larch wood). A helicopter (Fig.3 The helicopter transporting the tower, photo) transported the 20 m high tower from the settlement of Tura to the study

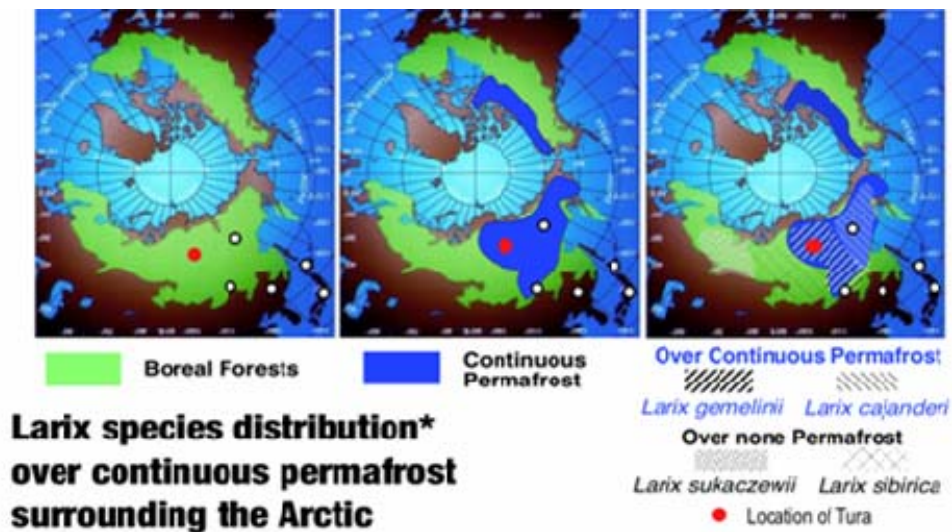


Fig.1 Distribution of Boreal forests, Continuous Permafrost, and Larch forests

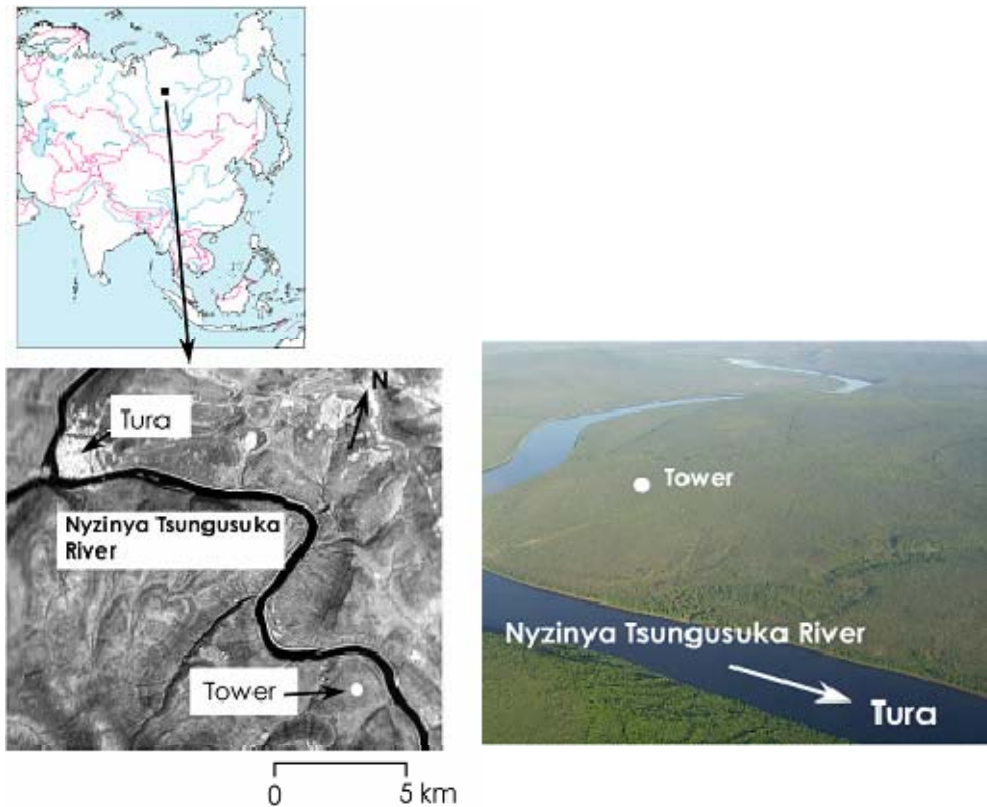


Fig. 2 Location of Tura and the tower site.



site, where it was set in place in August 2003. All meteorological instruments had been transported to Krasnoyarsk from Tokyo by mid June 2003, but had not been passed through the customs inspection by August 2003. Finally, we were able to set up all the equipment and start recording data in early June 2004 (Fig.4 Equipped Tower, photo). We well remember the long struggle to reach this point as if it was yesterday.

The objectives of this flux measurement project were to estimate seasonal and annual carbon dioxide exchange and to evaluate whether the Gmelin larch ecosystem functions as a carbon sink or source.

#### Site description

The flux measurement site ( $64^{\circ}12'N$ ,  $100^{\circ}27'E$ , 250 m above sea level) is located 25 km upstream from the settlement of Tura along the Nyzinya Tsungusuka River (a primary branch of the River Yenisey), in central Siberia, Russia (Fig.2). Uniformly aged, 105-year-old Gmelin larch trees grow at the site owing to regeneration after an extensive fire in the late 1890s. The site is located on slightly sloping terrain and the prevailing winds are westerly. According to tree census data collected from four permanent plots near the study site (Kajimoto *et al.*, 2004, 2007), the stem density of living larch trees is about 5000 trees  $ha^{-1}$  with a mean height of 3.4 m. Individual tree crowns are very slender and rarely overlap. Consequently, the larch stand has very sparse canopies (Fig. 5 Sparse canopy of the larch trees, photo down-looking from the tower). The leaf biomass of the stand is 0.42 Mg dry matter  $ha^{-1}$ , and the leaf area index (calculated as projected needle area) is estimated to be  $\sim 0.3 m^2 m^{-2}$  (Kajimoto *et al.*, unpublished data).

The soil type is cryosol (gelisol in USDA Soil Taxonomy) with the permafrost table existing within the upper 1 m of the soil profile (Matsuura *et al.* 2000). The parent material is old fluvial deposits of the Nyzinya Tsungusuka River. The soil texture of the surface-active layer is clay rich. The ground surface is densely covered with lichen and mosses, mainly *Cladina stellaris*, *Cetraria cucullata*, and *Pleurozium schreberi*, and organic matter (including roots and litter). This cover forms a thick porous layer 10–20 cm in depth above the mineral soil (Fig.6 Forest floor, upper: surface, lower: profile of soil surface), which functions as a heat insulator above the mineral soil.



Fig.3 The helicopter, transporting the tower to the site (photo by Dr. Matsuura)



Fig.4 Equipped Tower

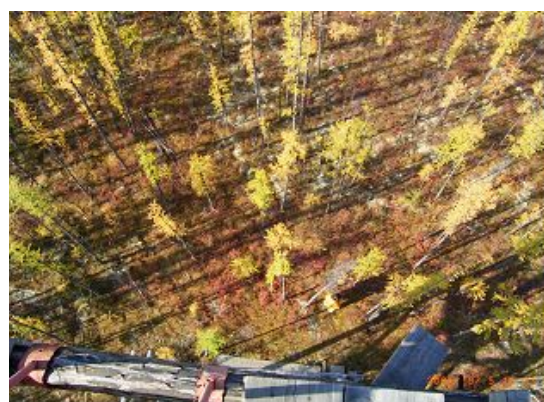


Fig. 5 Sparse canopy of the larch trees



Shrubs such as *Betula nana*, *Ledum palstre*, *Vaccinium uliginosum* and *V. vitis-idaea* which attain a height not exceeding 1.0–1.5 m, grow on the forest floor. These ecosystem characteristics are representative for the central Siberian permafrost region.

According to the long-term (1968–1992) meteorological data for Tura, the climate of the study site is extremely continental (Fig. 7). The mean annual air temperature is  $-8.9\text{ }^{\circ}\text{C}$ . The average air temperature between June and August is  $14\text{ }^{\circ}\text{C}$  with large daily variations of between  $0$  and  $30\text{ }^{\circ}\text{C}$ . The mean difference in air temperature between daily maximum and minimum exceeds  $20\text{ }^{\circ}\text{C}$  in July. The mean monthly air temperature is lowest in January at  $-36\text{ }^{\circ}\text{C}$  (the area is one of the coldest places in the world's boreal-forested zones) and highest in July at  $17\text{ }^{\circ}\text{C}$ . The maximum summer air temperature sometimes exceeds  $30\text{ }^{\circ}\text{C}$  and the winter temperature falls as low as  $-50\text{ }^{\circ}\text{C}$ . The mean annual precipitation is  $\sim 360\text{ mm}$ , of which 46% falls between June and August. The snow-cover period lasts from November to April.

### Measurements description

Carbon dioxide, water vapor, heat and momentum fluxes are measured at the top of the tower from June to early September, using the eddy covariance technique (Fig.8 Arrangement of devices at the tower). A three-dimensional sonic anemometer (Gill Solent R3; Gill Instruments) and a fast-response open-path infrared  $\text{CO}_2/\text{H}_2\text{O}$  gas analyzer (IRGA) (Li-7500; LiCor) are set on top of the tower. Raw voltage signals from these eddy sensors are recorded at 10 Hz on a data logger (CR-5000; Campbell). The IRGA was calibrated against standard gases in a laboratory in Tura before and after the measurement period. We collect the raw eddy data twice during the measurement period between June and early September. The raw eddy data is quality-controlled by FFPRI FluxNet software (Ohtani, *et al.*, 2005) and we calculate half-hourly eddy covariance fluxes of sensible heat, water vapor and  $\text{CO}_2$ . To estimate daily and seasonally integrated values of NEE, 'gap-filling' of half-hourly NEE data is performed. In the gap-filling procedure, gaps in the day-time NEE data are filled using rectangular hyperbola functions with a respiration term because most of nighttime periods have stable atmospheric condition and experimental parameterization of ecosystem respiration has a large uncertainty.

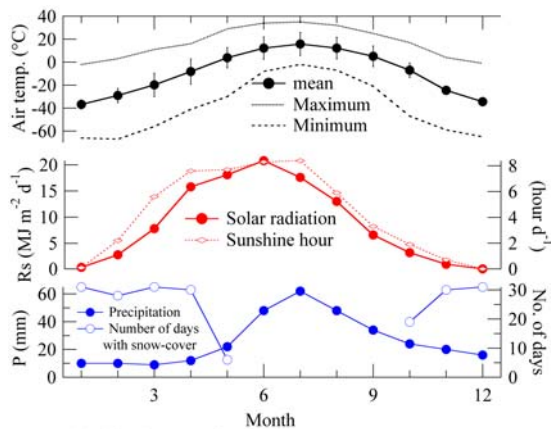
Standard micro-meteorological variables are also measured at the top of the tower to substantiate the flux measurements. Air temperature and relative humidity are measured using a resistive platinum thermometer and capacitive humidity sensor (HMP45A; Vaisala), respectively, within an aspirated radiation shield. Wind speed and direction are measured using a propeller anemometer (RM Young, 5103). Precipitation is measured using a tipping bucket gauge (0.5 mm per count; T34, Ohta keiki). Air pressure is measured using a capacitive sensor (PTB210; Vaisala) in the connection box for the IRGA. Global and reflective radiation for short-wave, long-wave and photosynthetically active radiation are measured using a four-component net radiometer (CNR1; Kip & Zonnen) and two quantum sensors (Li-190SB; LiCor), which are fixed on the top of a 1.2 m long horizontal boom at the top of the tower.

Downward solar radiation and photosynthetically active radiation at a height



**Fig.6 Forest floor**  
(upper: surface, lower: profile of soil surface)





Monthly Climatic Data of Tura. Error bar with monthly mean air temperature indicates mean daily difference. Data from Paul E. Lydolph (eds ) 1977, World Survey of Climatology (volume7), Climates of the Soviet Union

Fig.7 Climate of Tura.

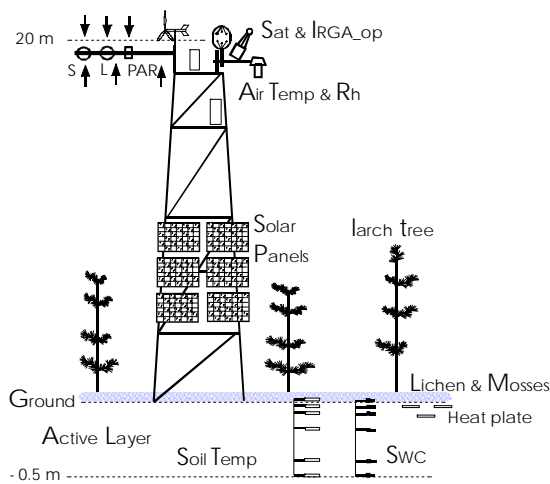


Fig.8 Arrangement of devices at the tower.

of 1.1 m above the forest floor are measured using a pyranometer (CM03; Kipp & Zonnen) and a quantum sensor (Li-190SB; LiCor). Soil temperature, moisture and soil heat flux at a 10 cm depth below the forest-floor surface are measured using resistive platinum thermometers (JIS-Pt100 4-wire type), TDR sensors (CS616; Campbell) and soil heat flux plates (HF-01; REBS), respectively, during the initial period between early June and late July 2004. Soil temperature and moisture are measured at depths of 5, 10, 20, 40 and 50 cm, and soil heat fluxes are measured at depths of 2 and 5 cm. For all micro-meteorological variables a half-hourly average is calculated and recorded by a data-logger (CR-10X; Campbell). Electricity for all devices is supplied with six solar panels (110 W maximum for each) through the deep cycle batteries. The whole integrated measurement

system (CFX-N1; Climatec) has been operated stably.

At the Tura station of Russian Federal Service of Hydro-Meteorology, we set up another system for measuring standard meteorological variables such as air temperature, humidity, solar radiation, wind speed, and precipitation throughout the year. This provides meteorological data during the periods without the tower flux measurements. This allows estimation of the fluxes in early spring and in late autumn when we sometimes can not access the tower site owing to ice in the river and snow cover.

### Findings and Future Perspectives

The larch canopy intercepted only 20-30 % of global solar radiation. This clearly indicates that the larch canopy is sparse and that light penetration is not a limiting factor for the forest-floor vegetation.

According to the combination of micro-meteorological measurements and phenological observation, net ecosystem exchange seems to vary seasonally as follows: 1) net uptake of CO<sub>2</sub> increases coincidentally with the development of the larch needles during 2-3 weeks; 2) maximum net uptake continued for further 2-3 weeks between late June and mid July; 3) the net uptake gradually decreased to zero by the end of August. Increase in NEE during the early growing season is likely to be related to needle phenology. Therefore, the larch trees seem to play an important role in the CO<sub>2</sub> budget of the ecosystem early in the growing season. However, the forest-floor vegetation receives sufficient radiation under the sparse canopy of larch and might contribute significantly to the ecosystem carbon budget. We need to partition the NEE into the forest-floor component (lichen, mosses and shrubs) and the larch-tree component, although the tree needles do not form a distinct canopy layer. During the period after the maximum net uptake of the growing season, both air temperature and incident radiation start to decline. We must examine the effects of seasonal changes of these two climatic factors but also the changes of leaf status to understand the decrease in NEE later during the growing season.

Generally, the flush of needle-leaf development starts in late May or early June in Tura. The leaves color to yellow in early or mid September, and fall by the end of September.



This indicates that the length of the larch growing season is only about 100 days per year. The timing of both the needle flush and senescence could vary between years within the range of two or three weeks. Thus, the length of the growing season might have considerable inter-annual variation from two months to 4 months even under the recent climatic changes. This expected inter-annual variation in the length of the growing season might have a large influence on the carbon balance of the ecosystem. For this purpose, measurements over multiple years are needed to obtain the inter-annual variability of seasonal patterns of the carbon balance and environmental variables.

Another interesting finding is that the magnitude of mid-summer net CO<sub>2</sub> uptake in the Tura larch forest is considerably smaller than those of mature boreal forests in other regions. This is likely due to the smaller LAI of the Tura larch forest, although such a small LAI is typical in the continuous-permafrost region. Clear relationships are not found between respiration and thermal variables since the nocturnal flux measurements provide fewer reliable data points during rather short length of nighttime at high latitudes in mid-summer. Chamber measurements might decrease the uncertainty in night-time NEE, which is essential for partitioning of the ecosystem carbon balance into respiration and gross photosynthesis productivity.

To conduct long-term studies at the Tura tower flux-measurement site, we require a strategy of field study at remote sites to reduce many problems, such as visiting the site for maintenance, transportation of devices, stability of electricity supply, and minimizing the number of variables measured.

#### Acknowledgements

We gratefully thank the late Dr. Anatoly P. Abaimov, Dr. Olga A. Zyryanova and colleagues of the Sukachev Institute of Forest, and Mr. Victor Borobikov of the Evenki forest management agency in Tura for field logistics. Many colleagues of the Japanese team also supported the measurements. We also thank Climatec Inc. for system integration and instrumentation. We acknowledge Dr. Yoshikazu Ohtani, Dr. Yukio Yasuda and Dr. Tsutomu Watanabe for providing software resources. Dr. Susumu Yamamoto and Dr. Nobuko Saigusa supported and encouraged us

greatly. This research was supported by the "Global environment research fund S-1", as "Integrated Study for Terrestrial Carbon Management of Asia in the 21th Century based on Scientific Advancements (FY2002-2006)".

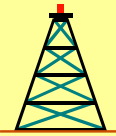
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### Site Info



## "Haenam" KoFlux Site

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### Site description

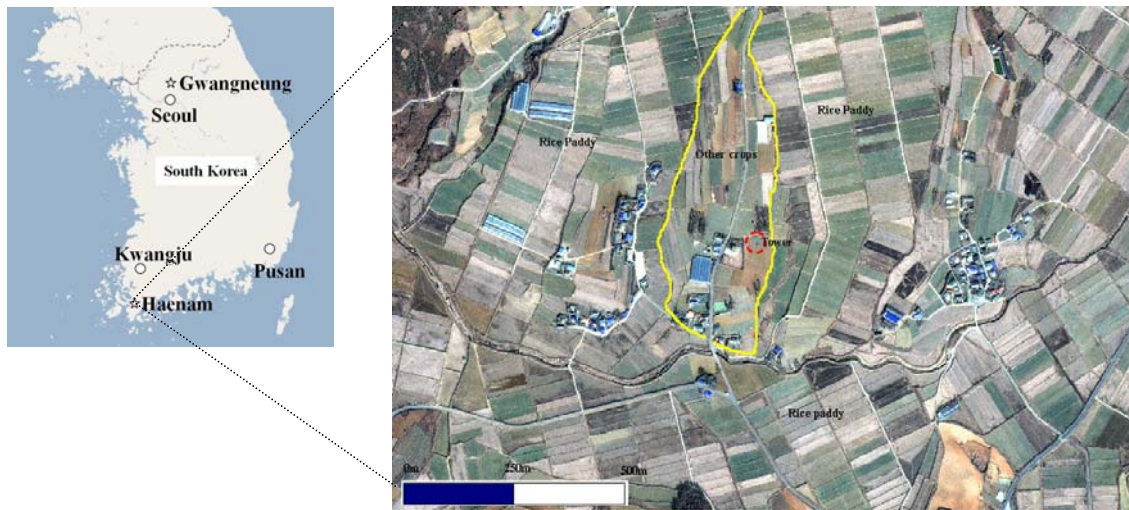
Haenam site is one of the KoFlux sites located at Haenam-gun, Jeollanamdo, near Southeastern coast of Korean Peninsula (34.55°N, 126.57°E, 13.74 m m.s.l.) The flux site was established in a local meteorological station of Korea Meteorological Administration (KMA) in July 2002, which represents typical heterogeneous croplands in Korea (Lee *et al.*, 2003). The land cover types around the site are farmland vegetation mixed with scattered rice paddies. Within the first 300 m around the tower, the major vegetation is seasonally cultivated crops such as beans, sweet potatoes, Indian millet, and sesame. Beyond this area, rice paddies prevailed in the south and the west. Also found around the tower are roads, small hills, residential areas, and scattered small forests (Fig. 1). In a regional sense, there are small towns, water reservoirs, and rivers.

The soil type at the site varies from silt loam to loam. Based on the estimation of vertical transform angle (Paw *et al.*, 2000), the site is relatively flat except the southeast section with a slope of about 4 degrees (Fig. 1). Topography around Haenam site is relatively flat at regional scale, except Wolch'ul

Mountain (809 m m.s.l.) and Duryun Mountain (703 m m.s.l.) which are located about 30 km north and 20 km south from the flux tower, respectively. It is also worth noting that the Haenam flux tower is about 30 km away from the ocean (Fig. 1). For the past 30 years, annual mean air temperature is 13.3°C with the maximum and minimum of 18.6°C and 8.6°C, respectively. The annual mean precipitation is 1,306 mm.

### Instrumentation

The surface flux measurements are being conducted on a 25 m tower along with occasional radiosonde measurements by Meteorological Research Institute of KMA. Eddy covariance system at Haenam site consists of three-dimensional sonic anemometer (CSAT3, Campbell Scientific, USA) and open-path H<sub>2</sub>O/CO<sub>2</sub> gas analyzer (LI7500, LICOR, USA) at 21 m above the ground (Fig. 2). Radiometers (CNR-1, Kipp & Zonnen, Germany) are also installed at 10 m above the ground. Two sets of soil temperature probes (TCAV, Campbell Scientific, USA), soil moisture probes (CS615, Campbell Scientific, USA), and soil heat flux plates (HFP01SC, Hukseflux, The Netherlands) are buried at 0.1



**Fig. 1** Haenam site in south Korea (left) and its IKONOS (right) images including flux tower in winter season.

m under the ground. Pan evaporation is also measured at the site. The radiosonde observations provide atmospheric pressure, geopotential height (gpm), relative humidity, wind speed, and wind direction. Sampling rate and averaging time for eddy covariance flux measurements are 10 Hz and 30 minutes, respectively. Data are saved and processed on a real time basis in a data logger (CR5000, Campbell Scientific, USA) and then transferred

to Linux file server at the biometeorology laboratory in Yonsei University through KMA intranet using FTP. Post-processings of the field data are executed in COMPAQ DEC workstation using data processing program of Hong and Kim (2002). More detailed information on micrometeorological and soil measurements at Haenam site can be found in Lee *et al.* (2003) and KoFlux website (<http://koflux.org>).

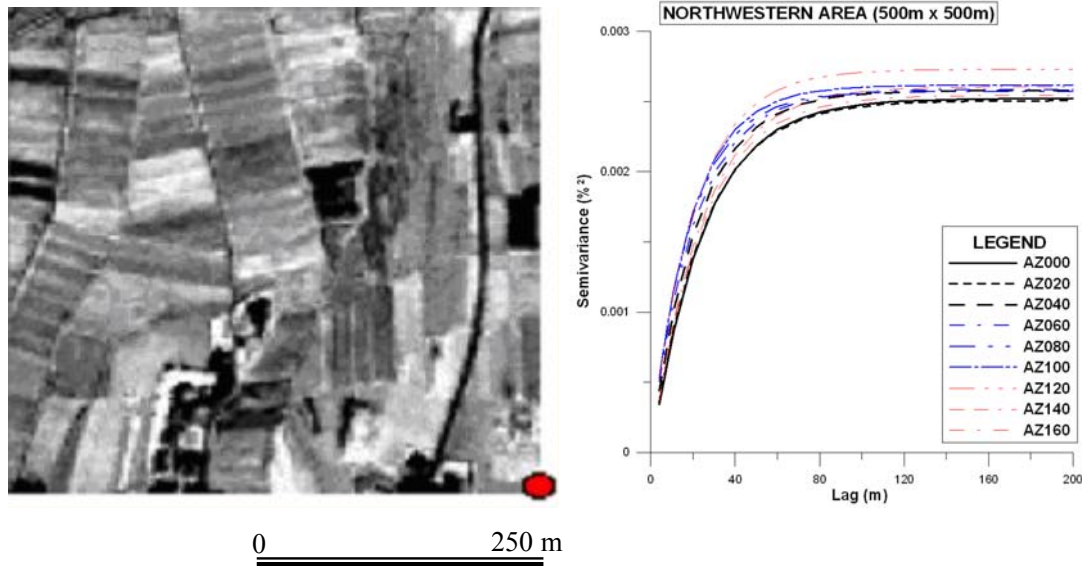


**Fig. 2** Eddy covariance system (top) and Autosonde (bottom) of Haenam site.

### Researches

Haenam flux site represents managed cropland ecosystems that are dominant in suburban and rural areas of the country. Outcomes from the site will elucidate energy and mass exchange processes in this disturbed ecosystem and improve quantitative estimates of the carbon sink strength in Korean peninsula. Typically, the summertime net ecosystem uptake (NEE) of CO<sub>2</sub> is of the order of 20 g m<sup>-2</sup> d<sup>-1</sup> whereas the wintertime net release of CO<sub>2</sub> is around 2 g m<sup>-2</sup> d<sup>-1</sup>. Changes in timing, frequency and intensity of precipitation during the monsoon and typhoon seasons result in interannual variations in NEE at this site.

Various approaches such as spatial analysis and modeling are conducted to assess water and carbon exchange at various temporal, spatial, and process scales. These efforts will help bridge the gap between plot scale field measurements (10<sup>-2</sup> ~ 10<sup>0</sup> km<sup>2</sup>) and the products of modeling and satellite image analyses at larger scale (10<sup>0</sup> ~ 10<sup>4</sup> km<sup>2</sup>). The spatial structures of the satellite-sensed patterns of various indices related to NEE and evapotranspiration are characterized by using



**Fig. 3** NDVI distribution in northwestern area around the flux tower (circle: tower) (left) and semivariograms of NDVI (right): AZ stands for azimuth angle for directional semivariogram. The ‘range’ is the lag distance where the semivariogram flattens, indicating the size of spatial structure. The ‘sill’ reflects absolute amount of heterogeneity (e.g. Cohen et al. 1990) and the ‘nugget’ represents the microscale variability such as sampling error (Levesque and King 1999).

semivariogram. For example, Fig. 3 shows the spatial structure of normalized difference vegetation index (NDVI) obtained from an atmospherically corrected IKONOS image over the Haenam farmland. The size of spatial structure ranges from 50 m to 80 m, indicating the characteristic length of the Haenam agricultural fields. Based on the IKONOS image (spatial resolution, 4m), the scale of heterogeneity of NDVI at Haenam site is less than 100 m. Such a spatial structure changes with season and wetting/drying cycle and should be considered in improving model algorithms, sampling strategies, and satellite image analyses. These efforts provide insights to how various information is transferred across scales, and hence how to simplify and aggregate measurements, models and satellite products.

Haenam site is one of the participating stations of the KEOP (Korea Enhanced Observing Program) that aims to efficiently monitor high-impact weather in mesoscale weather system passing through the southwestern part of Korean Peninsular. The second intensive observation was made from June with the onset of Asian Monsoon to July before the arrival of typhoons in 2006. Active collaborations are also underway to develop and validate various ecohydrological and

biophysical models. Lee *et al.* (2006) examined the sensitivity of the simulated diurnal patterns of surface fluxes to leaf area index (LAI) and maximum carboxylation rate ( $V_{cmax}$ ) at two different stages of crop growth in Haenam site using modified Soil-Plant-Atmosphere model (mSPA). The model simulates reasonably the magnitude and diurnal variation of latent heat flux and  $CO_2$  flux in low and near maximum LAI condition. The sensitivity of cumulative gross primary productivity (GPP) to LAI was much larger than that to  $V_{cmax}$  during the growing season in Haenam site, emphasizing the importance of accurate LAI estimate for better estimate of cumulative GPP.

The data collected at Haenam site are currently being processed through quality control and soon will be submitted to the AsiaFlux Database system to facilitate integrative and intercomparative studies. We look forward to any collaborations with scientists in AsiaFlux and other research communities.

**Acknowledgement**

This study was supported by the Eco-Technopia 21 Project (Ministry of Environment), BK21 program (Ministry of Education and Human Resource), and KEOP (Ministry of Science and Technology) of Korea. We express our sincere thanks to officers at



Haenam meteorological office of KMA for their support and technical assistance.

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## AsiaFlux Database has been Launched

Takashi Hirano (Leader of database sub-working group, Hokkaido University)

We would like to announce that we have just launched AsiaFlux Database system on the following website: <http://www.asiaflux.net/datapolicy.html>

AsiaFlux Database contains tower flux observation data with micrometeorology data at the moment, however, we are planning to extend it to an integrated database for whole terrestrial ecosystems in Asia, which covers soil respiration, ecological information, remote sensing and modeling research data. We hope this system will help promoting your study. AsiaFlux Database is in very early phase of its development. You might find some inconveniences while using this system. We would appreciate any opinions or suggestions. We will make every effort to honor your request.

To use AsiaFlux database, you need firstly to enroll yourself as AsiaFlux Member to obtain AsiaFlux ID and password. Once you become an AsiaFlux Member, you can access to the Member's Area and then there is AsiaFlux Database User registration form ("Obtain DB User ID" menu) in that area. For detailed procedure, please refer "ID and Password" section in the above mentioned web site. We ask that you will also read "Fair-use policy" and "Data Downloading Procedure" carefully and abide them when you use AsiaFlux Database.

We are truly pleased to welcome all researchers in Asia who are willing to utilize their research outcome by sharing your data with us. Our data policy ensures data providers' right and the close communication with data users. When someone is downloading your data from our system, you will be informed simultaneously by email. By opening your data to the public and encouraging the use of them to other researchers, it will result in the new progress in your study as well as returning the results of research to society. If you agree with our data policy, please send your dataset to our Database manager, Dr. Ryuichi Hirata (NIES, Japan) by email ([asiafluxdb@asiaflux.net](mailto:asiafluxdb@asiaflux.net)) with required information files (please refer Data Submission Guideline: <http://www.asiaflux.net/datasubmit.html>).

If you have any questions about data submission or usage, please contact also [asiafluxdb@asiaflux.net](mailto:asiafluxdb@asiaflux.net).



## AsiaFlux Workshop 2007

The 6th AsiaFlux workshop will be held in Taiwan where mountain terrain and mosaic forest cover posing difficult site conditions for flux measurement. We are hoping to organize a special session focus on flux measurement at sloping terrain. As usual, other aspects of biogeochemical processes and scaling-up models will be discussed during the workshop.

Date and Venue: October 19 – 21, Taipei, Taiwan

Organized by AsiaFlux Workshop Management Sub-workgroup

Jointly-Organized by National Dong Hwa University



AsiaFlux Newsletter  
March 2007, Issue No.21

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### Editor's Note

In winter, we have much snow in Sapporo. Now, I am clearing snow from the roof of observation lodge. I am thankful to authors, committee members and secretaries of AsiaFlux for their support.



The editor of AsiaFlux Newsletter No.21:

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The editor of AsiaFlux Newsletter No.22 will be Takeshi Saitoh (Forestry and Forest Products Research Institute).