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Present Status of AsiaFlux Network and Measurement Results of CO_2 Flux

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1. Introduction

Elucidation of circulation and budgets of carbon, water and other mass at various land ecosystems have become an important subject in the global change issue. In the climatic change study, the improvement of land surface hydrology models to get more accurate results and the verification of models by using observed data become the important subject to be solved. On the other hand, the establishment of scheme which estimates the whole land carbon balance as an global scale using the satellite observation data has been started, and the collaboration with the land observation is necessary.

With the aim of the elucidation of these subjects, the studies to grasp the mass exchange process between land surface, land ecosystem and atmosphere accurately and its modeling studies based on observation data are indispensable. For these studies, high-precise and long-team observation data of carbon dioxide, water vapor, and heat flux, etc. in various land surface and land ecosystems has become more and more important. Furthermore, in order to promote the flux observation, the cooperative activities among researchers of various fields such as micrometeorology, water management and hydrology, agro-meteorology, forestry, plant ecology, and thus synthetic analysis according to the accumulation of various observed data including atmosphere, vegetation, soil condition are demanded.

In order to estimate the mass balance as whole earth, the scale-up of results from plot scale flux observation to the global scale is important. Also, the accumulation of results from the individual flux observation, integration of results on flux observation at various types of ecosystems in the world are demanded. From the viewpoints above, flux observation at various types of ecosystems and land surface in the world becomes important.

2. FLUXNET Project and AsiaFlux Network

The project of FLUXNET aims to quantify the spatial and temporal distribution of biosphere sources and sink on a regional and global scale and to understand the factors that regulate net sequestration of anthropogenic CO_2 through biospheric processes. From this view, FLUXNET coordinates the establishment and operation of a global network of long-term sites, of which the European Commission-supported EUROFLUX network was one of the first pioneers. At present, similar networks exist in North America (AmeriFlux), and others are being implemented in the Mediterranean, South America, eastern Asia and Australia.

[Objectives]

(1) to elcidate the carbon cycle in the terrestrial biosphere, and its relation with meteorological parameters and CO_2, H_2O and heat fluxes,

(2) to provide the objective data for validation of modeling of biophysical and ecological processes of representative ecosystems,

(3) to provide the data-set for estimation of regional and global carbon sequestration using biosphere & dynamic models and satellite data,

(4) to establish the system and analysis technique for long term measurements of fluxes.

[Present Status of CO_2 Flux Research and Network in Japan and Asia (AsiaFlux)]

The flux network activity in Japan was started under the steering committee in September, 1999. The network is named "AsiaFlux", and the "AsiaFlux" home page was opened in January, 2000.

Long-term measurements sites of CO_2 flux in Asia by Japanese researchers are: about 12 sites in Japan and Korea, about 3 -5 sites in Thailand and Siberia at present and about 1-2 sites in Japan ,and 2 sites in China and Indonesia under planning. And, research groups of flux measurement are about 18.

[AsiaFlux Actitivies]

AsiaFlux promotes the research potential of flux studies of carbon dioxide, water and heat flux in Japan and Asia, and will contributes to FLUXNET Project, especially results in the Asian forests under monsoon climate and specific disturbance in Asia. AsiaFlux activities are as follows:

1) Maintenance of the home page of AsiaFlux, which sends information on flux studies and acts as interchange of researchers,
2) Promotion of holding of the scientific meeting and workshop on flux study, which improves cooperative activity and information exchange between the model study and field observation,
3) Support of the cooperative observation among different groups and comparison among various techniques,
4) Preparation of the establishment of the flux database and the examination of its contents and operation.

3. Some Results of Long-term CO_2 Flux Measurement

3.1 Seasonal and Inter-annual Variation of the CO_2 Uptake Rates at a Cool temperate Deciduous Forest in Japan

The measurements of CO_2 flux and meteorological conditions using a tower (height=27m) in a temperate forest of the middle of Japan (36 08' N, 137 25' E) were started from October, 1993. The tower was situated on one of the hills about 15 km east from Takayama City and the elevation of the site is about 1400 m above sea level. The undulation of the surrounding area in radius of 500 m is about 100 m. The topographical effects to wind and turbulence should be considered in the estimation of the fluxes.

Annual mean temperature was about 7.3 ℃ and the monthly averaged temperature reached 20 ℃ in August and -4.8 ℃ in January. The main species of trees in the site were deciduous broad-leaf trees such as birch (Betula ermanii, Betula platyphylla) and oak (Quercus mongolica), and average height of the trees (canopy height) was about 17 m. This is a protected forest, therefore human disturbances should be few during the recent 40 years. This site was covered by snow from December to April, and the beginning of June was the budding time and the beginning of October was the deciduous period of leaves. According to the variations of LAI, the most active season of photosynthesis is from the end of June to the beginning of September. CO_2 flux in daytime is positive (uptake by the forest ecosystem) from May to October and negative (outgoing to the atmosphere) from November to April.

Fig.1 shows the seasonal and inter-annual variations of integrated uptake rate of CO_2 for daytime, night and whole days for each month from October, 1993 to December, 1998. There was a notable differences of the seasonal variation of CO_2 flux in these years. The causes of difference in the value of CO_2 uptake were analyzed through comparison of the CO_2 flux with meteorological conditions in these years. Possible factors of difference in CO_2 flux are differences of air temperature and snow conditions in March and April, extension time of leaves in May and June, activity of rainy season (Bauiu in Japan) in June and July, insolation, precipitation and disturbance by typhoon in August and September.

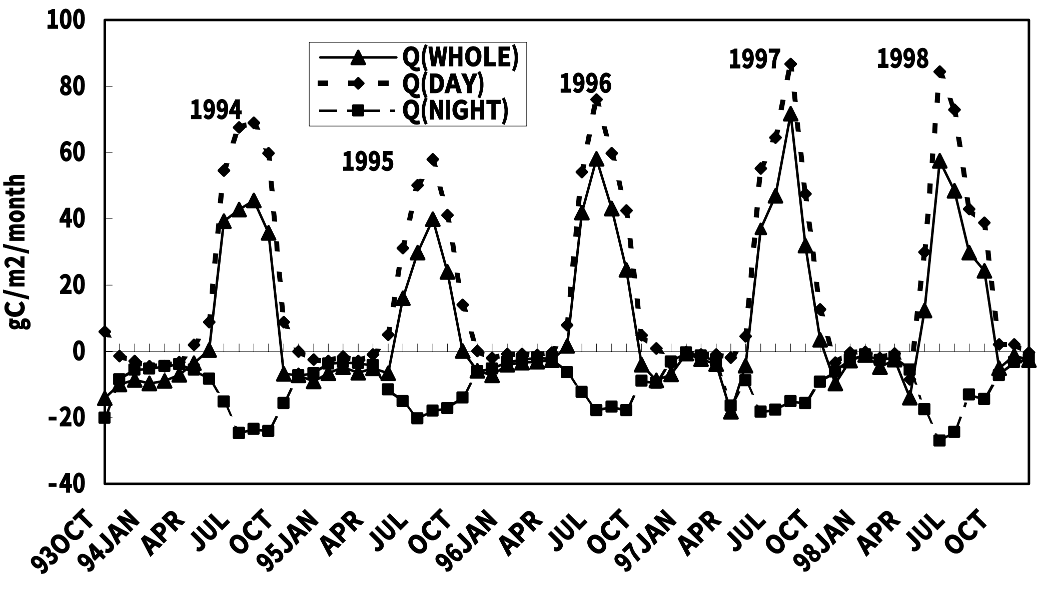

Fig. 1. Seasonal and inter-annual variation of integrated uptake rate of CO_2 for daytime, night and whole days in each month from Oct.1993 to Dec.1998 (Yamamoto, S. et al., from proceeding of International Workshop for Advanced Flux Network and Flux Evaluation,2000).

Table 1. Integrated uptake rate of CO_2 (gC/m^2 /year) for daytime, night and whole days from 1994 to 1998 at Takayama (a) and from 1997 to1999 at Kawagoe (b) , Japan.

(a) Takayama	Year	Q(Whole)	Q(Day)	Q(Night)	(b) Kawagoe	Year	Q(Whole)
	1994	112	256	-144		-	-
	1995	67	189	-122		-	-
	1996	136	239	-103			
	1997	149	263	-114		1997	357
	1998	177	290	-113		1998	317
	-	-	-	-		1999	227
	Mean	128	247	-119		Mean	300

(refer from proceeding of International Workshop for Advanced Flux Network and Flux Evaluation, 2000)

Next, integrated uptakes of CO_2 at various deciduous broad-leaved forests are considered using the network data. The yearly integrated uptake amounts of CO_2 at a cool-temperate deciduous forest (Takayama Japan) measured by Yamamoto, S. et al., and at a warm-temperate deciduous forest (Kawagoe, Japan) measured by Watanabe, T. et al., Forest and Forest Products Research Institute are shown in Table 1. Most important factor of the difference of integrated uptake rate of CO_2 (gC/m^2 /year) among deciduous broad-leaved forests is length of growing season (extension time of leaves and deciduous time). Also, affection of human impact in carbon uptake should be considered. Relation between NEE (Net Ecosystem Exchange) and length of growing season at broad-leaved forests using world flux database is shown in Fig.2. by Baldocchi, D. et al..(submitted to Bulletin of American Meteorological Society, 2000).

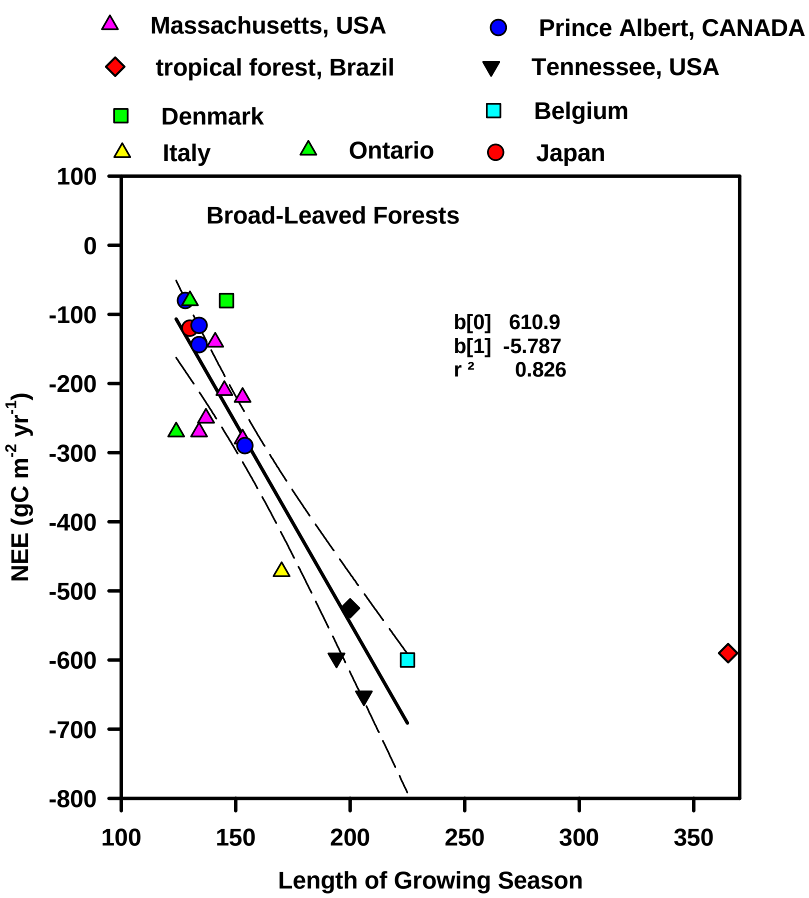

Fig.2 Relation between NEE and Length of Growing Season at Broad-Leaved Forests (Baldocchi, D. et al.,2000)

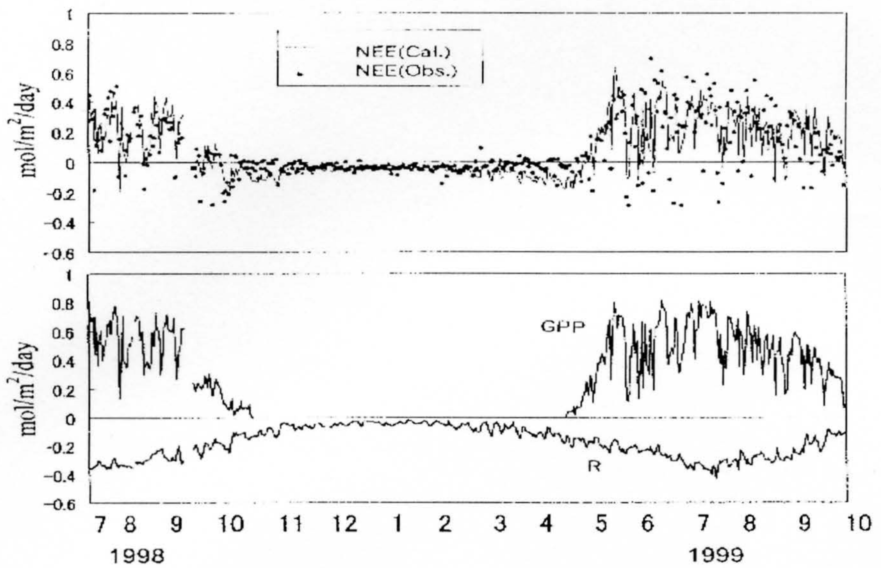

Fig. 3 Seasonal changes in the daily NEE, R and GPP from 25 July 1998 to 24 July 1999 estimated using experimental relations.

3.2 Parameterization of Respiration and Gross Primary Production

From the analysis of the relation between CO_2 flux and meteorological conditions, soil respiration, gross primary production (GPP) and the net ecosystem exchange (NEE) of the forest were parameterized as a function of the air temperature and the absorbed photosynthetic active radiation (APAR) as follows;

$$R=A\cdot Q^{(T-10)/10} \quad : A=0.17\ \mathrm{molCO2m^{-2}day^{-1}} \quad Q=2.57$$

$$GPP=b\cdot APAR/(1+a\cdot APAR) \quad NEE=GPP-R.$$

In these equations, parameters A, Q are estimated using the data under the nearly-neutral atmospheric condition in nighttime and parameters a, b are estimated from regression lines between APAR and GPP(=NEE+R) in each month. Procedure of analysis in detail are explained in Saigusa et al. (proceeding of International Workshop for Advanced Flux Network and Flux Evaluation, 2000).

Seasonal changes in the daily NEE, R and GPP from 25 July 1998 to 24 July 1999 estimated using above relations are shown in Fig. 3. Closed circles in this Figure are the observed NEE, and solid lines are the NEE calculated using experimental equations. The results show a clear seasonal change in GPP caused by changes in the light-use efficiency and the maximum rate of carbon fixation of the canopy with LAI. The estimated NEE based on the parameterization agrees well with the observed NEE during the observational period.

4. Conclusions

There are several issues for the quantitative estimation of CO_2 flux by the eddy covariance method. For the first step, the consideration of the energy closure problem may be effective to resolve the causes of flux errors. The possible causes of them are advection due to topographical and atmospheric conditions, and damping of high-frequency fluctuations. And, almost of the sites in Asia including Japan were set in complex topographical condition, therefore the analysis and estimation method of CO_2 exchange under complex condition should be established.

There are three lines of research to solve these problems as follows;

1) Comparison CO_2 flux estimated by eddy covariance using tower with Spatial CO_2 measurements using tethered balloon and airplane,
2) Comparison CO_2 flux estimated by eddy covariance method with biological survey (photosynthesis and respiration),
3) Conjunction of the measurements and numerical simulation of turbulence and fluxes using LES (Large Eddy Simulation) model.

On behalf of the "AsiaFlux" steering committee, we appeal to researchers of flux study on carbon dioxide, water vapor and energy, also to modelers whom interests in results from flux observation for joining in the AsiaFlux. Then, we ask to member of AsiaFlux to integrate the flux study result into an AsiaFlux information and to share and utilize them through the activities of flux workshop and collaborative field.