광릉 활엽수림에서의 여름철 수증기와 이산화탄소 연직 구조의 일변화

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Diurnal variation of vertical profiles of water vapor and CO_2 concentrations in Gwangneung deciduous forest in summer

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1. INTRODUCTION

We have installed the H_2O/CO_2 concentration profile systems on the flux tower within Gwangneung Deciduous Forest and evaluated the relevance of estimates of tower evaporation and CO_2 flux measurements by eddy-covariance over complex and heterogeneous terrain. We have examined the H_2O/CO_2 concentration profiles in terms of the storage and advective fluxes as well as the turbulent eddy fluxes, which are important to interpret carbon and water exchanges in typical forest in Korea.

In this presentation, we describe the H_2O/CO_2 profile system and show the preliminary results observed during summer season. We also discuss the characteristics of the observed field data in Gwangneung forest by comparing with the results reported from other sites.

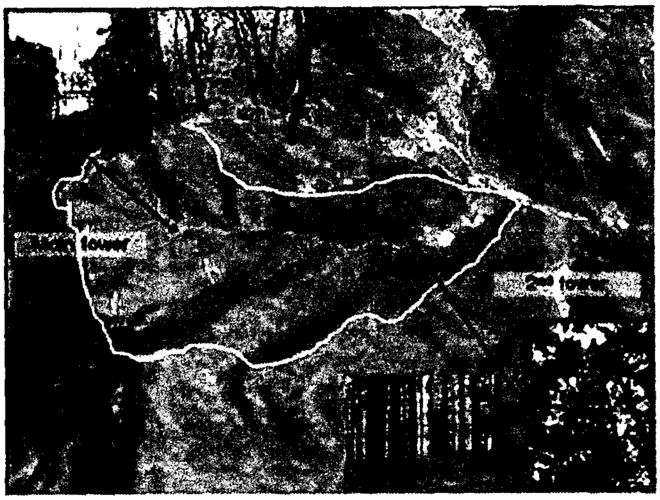

Figure 1. DK KoFlux site in Gwangneung Forest

2. SITE DESCRIPTION

The measurement data applied in the present study were made at the two flux stations in DK KoFlux site in Gwangneung research forest near Seoul, Korea (374525.37N, 127911.62S; 290 m.s.l.) (Fig. 1). The main 40 m tower (MT) is located in forested intermountain basins and surrounded by hilly terrain (290 m.s.l.). The terrain has a ~10 slope with the aspect of east dominantly (Moon et al., 2005). The second tower (ST) is about 1.2 km away from MT. ST is located near the lake (Yuk-lim ho) and on a relatively flat terrain (50 m.s.l.). The average canopy height was ~18 m and maximum foliage area index is ~ 6. The tree age ranges from 60 to 600 years and some trees were disturbed by severe thunderstorms during summer. More detail information on the species and soil composition can be found in Lim et al. (2003).

3. THEORY AND INSTRUMENTATION

The conservation equation provides the framework for estimating net ecosystem exchanges (NEE) of H_2O (evapotranspiration) and CO_2 (net ecosystem production) between forest and atmosphere (Finnigan et al., 2003; Aubinet et al, 2005).

$$NEE = \underbrace{\int_0^h \frac{1}{V_m}\left[\frac{\partial \bar{\rho}}{\partial t}\right]dz}_{I} + \underbrace{\frac{1}{V_m}\left(\overline{w'\rho'}\right)_h}_{II} + \underbrace{\int_0^h \frac{1}{V_m}\bar{w}(z)\frac{\partial \bar{\rho}}{\partial z}}_{III} + \underbrace{\int_0^h \frac{1}{V_m}\left(\bar{u}(z)\frac{\partial \bar{\rho}}{\partial x} + \bar{v}(z)\frac{\partial \bar{\rho}}{\partial y}\right)dz}_{IV} \quad (1)$$

where is the water vapor or CO_2 mixing ratio, V_m is the molar volume of dry air, u, v and $w$represent the instantaneous velocity components in the horizontal and vertical directions, respectively. Eddy-covariance method is only based on the turbulent eddy flux (term II). Therefore, we should carefully interpret the eddy-covariance data when turbulent eddy fluxes are not dominant and/or we are measuring over complex terrain.

Eddy covariance systems, composed of 3-D sonic anemometer (CSAT3, Campbell Sci., USA), open path gas analyzer (LI7500, LiCor, USA) and data logger (CR5000, Campbell Sci.), have been deployed at 19 and 40m at MT and 40 m at ST above the ground. To supplement these eddy covariance systems, we recently deployed the H_2O/CO_2 concentration profile systems at MTafter lab tests. This profile system consists of the closed path analyzer (LI6262, LiCor), E type fine wire thermocouple (FW1, Campbell Sci.), diaphragm vacuum pump (KNF, Germany), the switching module (SDM-CD16AC, Campbell Sci.) and data logger (CR23X, Campbell Sci.). The calibration for LI6262 has been done automatically per a day by the data logger. H_2O/CO_2 concentrations have been measured at 0.1, 1, 4, 8, 12, 20, 30 and 40 m. Cup anemometer were also used to measure wind speed at six levels (0.3, 4, 9, 14, 19, and 29 m).

4. RESULTS

Because the prevailing winds are protected in basins and the stations are surrounded by a rough tall forest in basins, the mean wind speed is not so strong (~ 1 ms^{-1}), and so thermally induced circulation (e.g., mountain-valley circulation) is dominant than the terrain forced flows by synoptic motions. Our results confirm the heterogeneity of Gwangneung forest. Turbulent eddy fluxes at two towers show about 10 % differences in spite of similar radiation forcing. The apparent terrain slope at MT was steeper than at ST. Moreover, the apparent slope showed the variability with height and atmospheric stabilities at MT. It implies the two eddy covariance systems at MT view at different source/sink areas, which can account for the differences among the eddy-covariance systems in part.

The H_2O/CO_2 storage fluxes were significant only during sunset and sunrise. The storage flux was positive during nighttime but negative in the morning (Fig. 2).Especially, abrupt changes of the storage fluxes occurred near sunrise with increase in the wind speed within the canopy. Two sets of eddy covariance system show the discrepancies of turbulent eddy fluxes and we can not fully explain such discrepancies with only the storage between 20 and 40 m. On the other hand, the storage fluxes summed to zero per ~ 2 days and it suggests that we should carefully consider the storage fluxes to properly estimate the daily integration of ET and NEP. We need more investigations to clarify the relationship with the atmospheric synoptic motions.

For the turbulent fluxes at MT, interpreting eddy-covariance data would require caution to assure the data quality (Fig. 3). Our eddy-covariance data shows the sharp drop in the morning and such abnormal drop may be filtered out by quality assurance. However, H_2O/CO_2 profile data show this change is closely related with the storage flux and/or perhaps advection effects. When H_2O/CO_2 concentration inside the canopy decreased rapidly with the enhancement of wind speed, the storage fluxes decreased but eddy fluxes increased sharply. Such consistent and sharp variations are clearly manifested at the lower measurement height. Furthermore, turbulent eddy fluxes did not approach zero in weak turbulence conditions. The results suggest that there should be sporadic 3-dimensional flows between 20 and 40 m at MT and therefore it is questionable to screen out ET and NEP with low friction velocity criterion. We can show this non-zero eddy fluxes in calm winds to be related with horizontal and advective fluxes after finishing the profile system and multi-level eddy covariance systems at ST.The present instrumentations are not sufficient to capture the advective fluxes. Especially, fast response wind sensors should be deployed within the canopy to properly estimate the advective fluxes. We are now installing another profile system and eddy-covariance systems in ST to capture the effect of 3-dimensional flows on ET and NEP. The PBL observations would provide useful information on the interactions with background flows (e.g., low level jet).

ACKNOWLEDGMENT

This research was supported by the Sustainable Water Resources Research Center of 21st Century Frontier Program (Project No. 1-8-2), Korea and by 'The Eco-Technopia 21 Project', Ministry of Environment.

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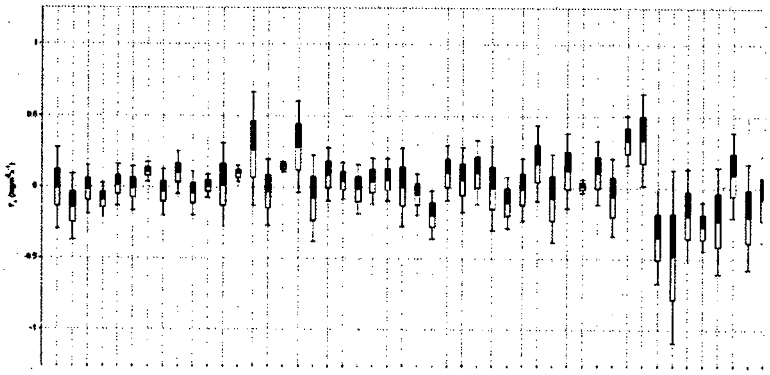

Figure 2. Diurnal variation of the storage fluxes. The data were averaged for 3 days and the vertical bar implies the standard error.

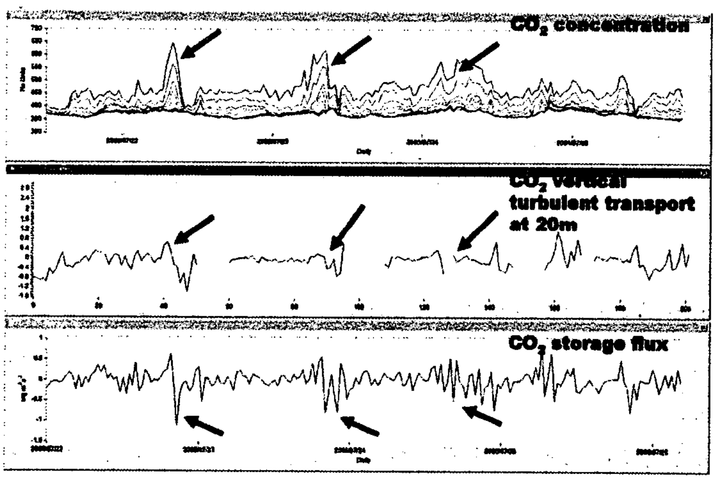

Figure 3. Diurnal variation of CO_2 concentration,turbulent eddy fluxes, and storage fluxes at MT. The data were averaged for 3 days and the vertical bar implies the standard error.