COMPARISON OF EDDY CO_2 FLUXES MEASURED WITH OPEN-PATH AND CLOSED-PATH SYSTEMS BASED ON A LONG TERM MEASUREMENT

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ABSTRACT

Evaluation of the difference between annual net CO_2 ecosystem exchanges (NEE) from the open- and the closed-path data is important for site intercomparison studies. However, long-term measurements of NEE using both systems have been limited. We report the comparison of eddy CO_2 fluxes measured with open- and closed path systems for three years from 2001 through 2003. The annual GPP estimated from closed-path data was 8–10% less negative than that from the open-path data, whereas the annual RE was 11–16% more positive for closed-path data. Consequently, the annual NEE from the closed-path data was less negative by 301–333 gC m^{-2} y^{-1}. The bias of NEE between two systems is large and an extremely important issue. Ecophysiological approaches are needed to validate of the eddy covariance technique.

1. INTRODUCTION

Long-term measurements of CO_2 flux by the eddy covariance technique using open- or closed-path systems on a tower have been performed for elucidating the carbon cycle of terrestrial ecosystems. Evaluation of the difference between annual net CO_2 ecosystem exchanges (NEE) from the open- and the closed-path data is important for site intercomparison studies. However, long-term measurements of NEE using both systems have been limited. We report the comparison of eddy CO_2 fluxes measured with open- and closed path systems for three years from 2001 through 2003.

2. SITE AND METHOD

2.1 Site Description

The study site is Tomakomai FRS, a Japanese larch plantation (*Larix kaempferi* Sarg.) in Tomakomai, Hokkaido, Japan (42°44'N, 141°31'E). The terrain was almost flat, with a slope between 1° and 2°. The area of the larch forest is about 100 ha, and the canopy height is 15–16 m. The tree age was about 45 years old. Canopy LAI reached 5.6 m^2 m^{-2} at the maximum in summer. There were scattered deciduous broadleaf trees (*Betula ermanii*, *Betula platyphylla*, and *Ulmus japonica*) and sparsely distributed spruce (*Picea jezoensis*). A 42-m tower was built near the forest center for measurements of fluxes and meteorology. Fetch was between 300 m for the north and 800 m for the west; it was 350 m for the south, which was the dominant wind direction. The forest floor was thickly covered with understory species, which mainly consist of fern (*Dryopteris crassirhizoma*) and *Pachysandra terminalis* with the maximum height of 0.9–1.4 m and maximum LAI of 3.6 m^2 m^{-2} in July. *Hirano et al.* [2003] and *Liang et al.* [2004] described site characteristics in detail.

2.2 Flux Measurements

CO_2 flux, sensible heat flux (*H*) and latent heat flux (lE) have been measured over the canopy by the eddy covariance technique since 2000 [*Hirano et al.* 2003]. Wind speed and virtual temperature were measured with a 3D sonic anemometer-thermometer (DA600, Kaijo), and CO_2 and water vapor densities were measured with open- and closed-path CO_2/H_2O analyzers (LI7500 and LI6262, Licor) at height of 27 m. The open-path analyzer was calibrated approximately every 2 months with standard CO_2 gases (0 and 500 ppm). The closed-path analyser was calibrated once a day with standard CO_2 gases (320 and 420 ppm) [*Wang et al.* 2004]. Data were sampled at 10 Hz through a low-pass filter with a cut-off frequency of 5 Hz, and half-hourly averages of fluxes were calculated without trend removal; double rotation and WPL corrections were applied, and sensor span and separation between sensors were corrected. NEE was calculated as the sum of CO_2 flux and CO_2 storage change in space below flux measuring height. Details of flux and meteorological measurements were described by *Hirano et al.* [2003]. *Wang et al.* [2004] provides details of the closed-path system.

3. RESULTS AND DISCUSSION

Half-hourly daytime NEE tended to be more negative by about 10% for open-path than for closed-path. In contrast, half-hourly nighttime NEE tended to be about 10% less positive for open-path than for closed-path.

The annual sum of NEE, GPP, and RE was estimated from closed-path data at 27 m by the same method as that used for the open-path data. Annual NEE, GPP, and RE with u* threshold of 0.2 m s^{-1} were: -135, -1454, and 1319 gC m^{-2} y^{-1} for 2001; -210, -1434, and 1224 gC m^{-2} y^{-1} for 2002; and -254, -1533, and 1279 gC m^{-2} y^{-1} for 2003, respectively. The three-year means of NEE, GPP, and RE were -200, -1474, and 1274 gC m^{-2} y^{-1}, respectively. Figure 1 shows annual cumulative GPP, RE, and NEE values measured with open-path and closed-path systems for 2001, 2002, and 2003. The annual GPP was 8–10% less negative than that from the open-path data, whereas the annual RE was 11–16% more positive than that from the open-path data. Consequently, the annual NEEs from the closed-path data were less negative by 301–333 gC m^{-2} y^{-1}. Some studies also have reported the large difference between NEE from open-path data and closed path data [*Anthoni et al*. 2002, *Miller et al.* 2005].

The bias of NEE between the open-path and closed-path methods is an extremely important issue. However, we cannot judge which method provides NEE closer to the actual one in this paper. Ecophysiological approaches, such as the chamber method and the harvest method, are necessary to validate the eddy covariance technique.

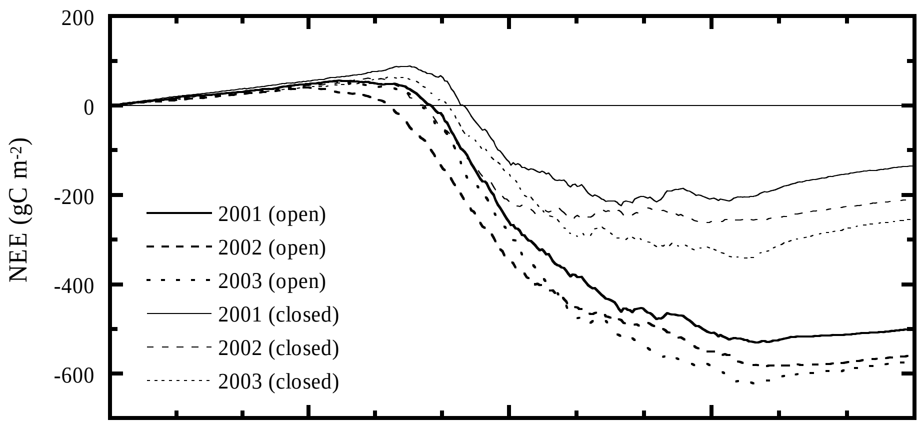

Fig. 1. Cumulative NEE measured by open-path and closed-path systems for the three years.

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