CO_2 GAS FLUXES IN GRAZING PASTURE

T.Oku, S.Shibata, S.Takahashi, M.Shibayama
National Grassland Research Institute, Nishinasuno, Tochigi, 329-27 Japan

ABSTRACT

CO_2 gas fluxes in grazing pastures were measured directly by the eddy correlation method to determine whether grasslands function as carbon sinks or sources. Observations revealed daytime CO_2 absorption fluxes to grassland and nighttime CO_2 emission fluxes to atmosphere. In 1993, the daily amounts of CO_2 absorbed by grassland were larger than those of CO_2 emitted to the atmosphere during the measuring period in spite of a cool summer and consequently lower level of solar radiation. In 1994, we obtained reverse carbon budgets especially on very hot days, which resulted from a different fluctuation pattern of the CO_2 gas fluxes. However, CO_2 absorption by grassland exceeded CO_2 emissions on many days during the year as observed in 1993. These results suggest that grasslands may function as carbon sinks.

KEYWORDS

Grazing pasture, carbon budget, CO_2 gas fluxes, eddy correlation method

INTRODUCTION

Atmospheric concentrations of CO_2 and other trace gases that induce climate warming are known to be increasing year by year.

Grasslands are said to account for 41% of terrestrial area except in the polar regions (Thornthwaite,C.W. 1948). The carbon storage ability of grassland is considered higher than other ecosystems, as confirmed by reports for example, on deep-rooted grasses introduced in the South American savannas (Fisher et al.,1994).

To clarify the mechanism of carbon cycling in the various type of grassland ecosystem, it is necessary to determine whether each grassland acts as carbon sink or source.

In this study, CO_2 gas fluxes in grazing pastures were directly measured to evaluate the carbon budgets between the atmosphere and grassland.

MATERIALS AND METHODS

These experiments were part of a continuing series conducted at the Experimental Field of Grassland Ecosystems in Fujinita Hill located at the National Grassland Research Institute in Japan. Fujinita Hill is about 340m above sea level. Forests remain on its northern slopes, native grassland and artificial pastures on the southern slopes. These pastures consist of several temperate grasses such as tall fescue (*Festuca arundinacea Schreb*), orchardgrass (*Dactylis glomerata L*), red top (*Agrostis alba L*), perennial ryegrass (*Lolium perenne L*), Kentucky bluegrass (*Poa pratensis L*) with white clover(*Triforium repens L*). In these pastures, rotational grazing experiments using cattle have been conducted over the last two decades.

We measured the CO_2 gas fluxes directly in grazing pastures by using an ultrasonic anemometer and a CO_2-H_2O fluctuation meter positioned above the vegetation. Fluctuations of wind speed, wind direction, temperature, atmospheric carbon dioxide concentration and water vapor content were measured. These turbulent fluctuation data were sampled at 10 Hz and gas fluxes were calculated every 10 minutes. CO_2 gas fluxes were corrected by using Webb's equations (Webb et al.,1985) for density effects.

Soil respiration rates were measured by the sponge absorption method (Kirita,1971) simultaneously when gas fluxes were measured. Biomass of herbage, root biomass, amount of litter and amount of herbage intake etc. were measured regularly in the same pasture during the measurement period.

RESULTS AND DISCUSSION

Fig.1 shows some observed examples of time variation of CO_2 gas fluxes, air temperature, solar radiation, latent heat and sensible heat in grazing pastures measured directly by the eddy correlation method.

Measurements of CO_2 gas fluxes. We had a cool summer and sub-normal level of solar radiation in 1993. In March, it was a fine day and CO_2 gas fluxes were transferred downward in the daytime, which means that CO_2 gas was absorbed and fixed vigorously to vegetation. At night, in contrast, CO_2 gas fluxes were transferred upward to atmosphere by plant respiration and soil respiration. Fluctuations in CO_2 gas fluxes were larger in the daytime than at night. The mean CO_2 absorption flux to grassland in daytime was 0.21 mg/m^2/s and the mean CO_2 emission flux to atmosphere was 0.06 mg/m^2/s. Later in a cool summer, we observed smaller fluctuations in CO_2 gas fluxes than in March, but time variations of fluxes showed a similar tendency.

We had a record-breaking hot summer in 1994, which was in marked contrast to the previous year. In July, it was fine and very hot, and we observed the different fluctuation pattern of fluxes. In the daytime, the CO_2 gas fluxes had slightly negative values, but CO_2 gas transfers downward were not large. At the same time, the air temperature was extraordinary high and latent heat fluxes were low, which means that photosynthesis was relatively less active. In contrast, CO_2 gas transfers upward were very large because of an increase of soil respiration rates. In this day, the mean CO_2 absorption flux to grassland in daytime was 0.05 mg/m^2/s and the mean CO_2 emission flux to the atmosphere was 0.06 mg/m^2/s.

Analysis of the values of CO_2 gas fluxes. In 1993, the fluctuation of CO_2 gas fluxes was largest in August. Both the absorption and emission fluxes were smaller from April to June. Vegetation was considered relatively less active because of cool weather and lower levels of solar radiation. In 1994, CO_2 absorption fluxes in the daytime were larger from late April to June and then smaller in the summer, which contrasts with the pattern in 1993. CO_2 emission fluxes and air temperature at night correlates sufficiently well that the amount of soil respiration ratio to the amount of CO_2 emission was inferred to be large.

CO_2 budgets between the atmosphere and pasture. Daily CO_2 budgets between the atmosphere and pasture are shown in Fig.2.
In 1993, the amounts of CO_2 absorbed by pasture were larger than the amounts of CO_2 emitted to the atmosphere except in one case (June 2). CO_2 intakes to pasture were higher in autumn, reaching a maximum of about 7.10 g/m^2/day (Nov. 17).

In 1994, on some summer days, the amounts of CO_2 absorbed by pasture were smaller than the amounts of CO_2 emitted to the atmosphere. In summer, daily CO_2 budgets tended to show small CO_2 intakes to pasture on cloudy days rather than on fine days. We thus inferred that when the air temperature was extraordinary high and transpiration of vegetation was restrained, photosynthetic capacity became lower, and as soil temperature increased, the decomposition rates of soil organic matter and litter both became higher. Reverse CO_2 budgets on these hot days were thus observed. On other days, however, the amounts of CO_2 absorbed by pasture were larger than the amounts of CO_2 emitted to the atmosphere as observed in 1993. CO_2 intakes in spring were especially large, with a maximum CO_2 intake to pasture of about 9.91 g/m^2/day (Apr. 30). These findings would suggest that grassland may act as a carbon sink during the year.

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Figure 1
Time vaiation of vertical fluxes of solar radiation (Q), air temperature (Tm), latent hear (LH), sensible heat (SH) and carbon dioxide over grazing pasture. Each flux indicates positive values when it is transported upward except solar radiation. (Measurements in March, 1993 and in July, 1994)

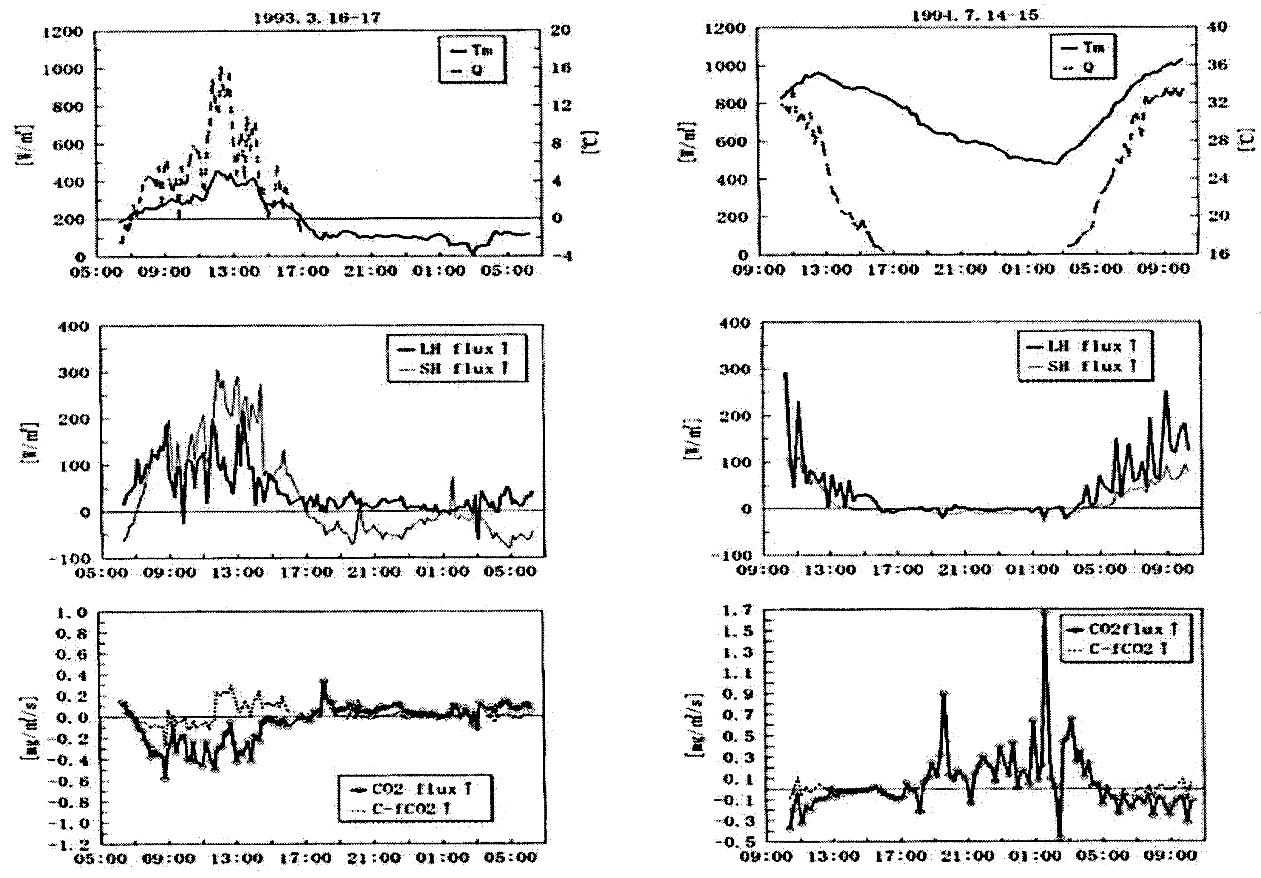

Figure 2
CO_2 budgets in grazing pasture (1993-1994)