CO₂ and Heat Exchange of Mangrove Forest in Thailand

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Abstract

CO₂ and heat fluxes of the mangrove forest in Thailand are investigated based on observation during a dry season. Clear diurnal change was seen in the sensible heat flux. There was a large amount of latent heat flux even at night. The latent heat flux was larger than the sensible heat flux. CO₂ flux changed sign between day and night. The magnitude of the upward flux during nighttime and the downward flux during daytime was about the same, which is considerably different from the flux characteristics during the wet season.

Key words : CO₂ flux, Latent heat flux, Mangrove forest, Sensible heat flux, Thailand

1. Introduction

Mangrove plants grow in the inter tidal zone of coastal area in the tropics and subtropics. Mangrove forests play important roles in providing a rich ecological environment and are appreciated as a nursery for various species of shrimp, fish and crab. They also produce wood and charcoal. However, mangrove forests have been widely developed into shrimp culture ponds or destroyed because of tin mining. The area of mangrove forest keeps decreasing rapidly throughout the world. Although it is urgent to protect and recover mangrove forests from the stand point of conservation of the global as well as the regional environment, information concerning the mangrove environment (Moor *et al.*, 1973; Attiwill and Clough, 1980; Andrews and Muller, 1985; Yabuki *et al.*, 1990, Monji *et al.*, 1996) is not sufficient. The objectives of this research are to investigate the characteristics of the CO₂ exchange and the energy budget of a mangrove forest to understand the micrometeorological environment based on a field experiment in Thailand.

2. Field experiment

The field experiment was carried out in a mangrove forest in Phangnga, south Thailand (8° 20'N and 98° 27' E). The measurements were made during a dry season from the end of March to mid April 1995. The site was selected about 0.5 km from a large creek to obtain a sufficient fetch. The site was covered with a homogeneous canopy. This was a 10-20 year old

Fig.1 Schematic diagram of the instruments installed on the platform.

secondary forest consisting of about 10 species.

The most predominant species was *Bruguiera cylindrica*. The average tree height was 4.4m, and the height of the tallest trees was about 8 m. The zero-plane displacement determined using cup anemometers was 4.3m. A platform with a height of 15.5m was constructed.

Estimation of CO_2 and heat exchange was made using the gradient method. Cup anemometers and aspirated thermocouple psychrometers were installed at height of 15.6 and 8.1 m. The air inlets for the CO_2 measurement were also placed at the same heights. Global radiation and net radiation were measured at the top of the platform. The arrangement of the instruments on the platform is indicated schematically in Fig.1. The temperature of the forest canopy was measured by a radiation thermometer installed at 15m on the platform. The tidal level of the nearby creek was measured by a tidal gauge.

3. Energy and CO_2 fluxes in the mangrove forest

Time variations of temperature indicate a typical diurnal variation, i.e., high temperature of the leaf and lower layer (near the canopy surface) during the daytime and opposite during the night. Specific humidity decreased during the daytime, but the gradient was in the direction of the upward vapor flux throughout day and night. Wind speed also indicates clear diurnal variations, i.e., high wind during the day. Strong winds in the afternoon which occurred almost every day were associated with downdrafts from thunderstorms.

Fluxes of heat and CO_2 were computed based on the gradient method. Since the flux gradient relationship over a forest canopy is not well known, the relation obtained using the data from the eddy correlation method for the sensible heat flux was used to estimate the nondimensional profile and stability relationship (Fig.2).

Fig.2 Stability dependence of the correction factor for the gradient method.

Fig.3 Time variation of the heat fluxes.

Time variations of the heat fluxes are indicated in Fig.3. A clear diurnal variation is seen in each component. The maximum global radiation exceeded 1000Wm^{-2} . The latent heat flux during the daytime is larger than the sensible heat flux by about three times. The latent heat flux during the nighttime remained finite while the sensible heat flux approaches near zero. There was a large amount of evaporation even when the net radiation was small. These large amounts of evaporations occurred in association with the afternoon thunderstorm down draft. On the other hand the sensible heat flux varies linearly with the net radiation.

The effect of the tidal level on the fluxes was not clear in this experiment. But, specific humidity seemed to increase during the spring tide.

Profiles of CO_2 during day and night is indicated in Fig.4. This suggests flux into the mangrove canopy during the daytime and in the opposite direction during the nighttime. Time variation of the CO_2 flux shows a clear diurnal change (Fig.5). During the daytime the direction is downward, i.e., flux is from the atmosphere to the mangrove. The direction is the opposite during the night, i.e., forest to atmosphere. The magnitude of the flux during the nighttime is about the same order of magnitude as that during the daytime except for some period. The magnitude of the daytime flux is considerably smaller than that in the wet season (Monji *et al*, 1996a). The relation between the flux and the global radiation indicates an increase in the downward flux with an increase in global radiation (Fig.6). The scatter may be caused by factors other than the radiation. The compensation point is slightly larger than that in the wet season. The soil respiration of the mangrove forest was also measured by the chamber method. It was an order of magnitude smaller than that in the land forest.

Fig.4 Profiles of CO_2 concentration.

Fig.5 Time variation of CO_2 flux.

4. Concluding remarks

The characteristics of the CO_2 and heat fluxes described above are considerably different from those obtained over a temperate coniferous forest in a dry season (Monji *et al.*, 1996b) or those over the same mangrove forest during the wet season (Monji *et al.*, 1996a). In the temperate coniferous forest, the sensible heat flux was larger than the latent heat flux, but in the mangrove forest it was the reverse. The latent heat flux went to near zero at night in the coniferous forest but it had substantial values in the mangrove forest. Downward CO_2 flux during the daytime in this experiment was about the same as the upward flux during the nighttime, but the daytime flux was much larger than the nighttime flux in the wet season.

The flux estimation was based on the gradient method, whose reliability is not well established over tall canopies like forests. We should establish useful flux-gradient relationships over forest for longer term observations.

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Fig.6 CO_2 flux as a function of global radiation.