LUND UNIVERSITY

FLUXES OF CO_2 IN SEMI ARID SUDAN*

CGB
GeoBiosphere Science Centre

Introduction

Much global carbon cycle research has been focusing on forests, whereas savannas have received less attention [1]. Savanna ecosystems cover a greater area than any forest biome [2] and are due to losses of vegetation and soil organic carbon a potential carbon sink [3, 4]. Taylor and Lloyd [5] estimated that 15% of the annual global carbon sink might be attributable to savannas and seasonally dry tropical forest ecosystems. Increased water use efficiency due to higher atmospheric CO_2 content may further enhance this potential [6].

A flux tower was recently established by us in central Sudan in the Sahel (13.3˚ N, 30.5˚ E), a region where recent vegetation changes have been observed [7, 8] and modeled [9].

This project aim to provide information on carbon dynamics and ecosystem functioning in a semi arid savanna.

Methods

Here we present flux data collected during the dry (Julian day 44-45) and moist season (Julian day 269-270) of 2005. The site is a sparse savanna with Acacia senegal and a ground cover of grass and herbs, located on a deep sandy soil. Mean annual precipitation is 320 mm and fall from June-October. November to May is dry. Mean annual temperature is 28˚C. Grazing, cultivation and forestry management are controlled. The last rain (2 mm) prior to the present dry season measurements occurred on October 18, 2004. The total precipitation in 2004 was 144 mm. Hence the soil was very dry during the dry season with a volumetric soil moisture of ≈ 5% in the upper 2 m. Approximately 350 mm of precipitation fell during the summer 2005 prior to the presented moist season measurements. Slightly higher volumetric soil moisture (5-9%) was recorded in the upper 2 m during the moist period presented. Maximum volumetric soil moisture recorded was 16% (Julian day 197) at 60 cm depth.

Measurement equipment included an open path infrared CO_2/H_2O analyzer (LI7500, LICOR) a Gill R3 Ultrasonic Anemometer, a net radiometer (NR-Lite, Kipp and Zonen) as well as standard devices. The gas analyzer and anemometer was mounted at 9 m height, approximately 4 m above the canopy. All data was stored as 30 min averages. The Webb correction of the data turned out to be essential for this open-path system.

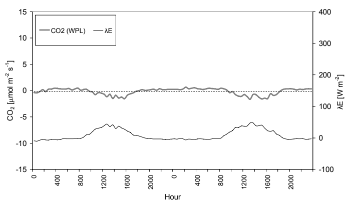

Fig 1. Dry season CO_2 flux and latent heat flux

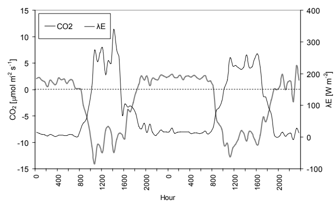

Fig 2. Moist season CO_2 flux and latent heat flux.

Results

Dry season, day- and night-time net ecosystem CO_2 fluxes peaked at -1.6 µmol m^2 s^{-1} and 0.6 µmol m^{-2} s^{-1} respectively. Mean day- and night-time fluxes were -0.7 µmol m^{-2} s^{-1} and 0.2 µmol m^{-2} s^{-1} respectively (Fig. 1). This corresponds to mean net assimilation of 0.014 mol CO_2 m^{-2} d^{-1} and a water use efficiency of 1.9 g CO_2 per kg H_2O.

Moist season, day- and night-time net ecosystem CO_2 fluxes peaked at –14.0 µmol m^{-2} s^{-1} and 4.4 µmol m^{-2} s^{-1} respectively. Mean day- and night-time fluxes were -6.4 µmol m^{-2} s^{-1} and 1.7 µmol m^{-2} s^{-1} respectively (Fig. 2). This corresponds to mean net assimilation of 0.21 mol CO_2 m^{-2} d^{-1} and a water use efficiency of 2.8 g CO_2 per kg H_2O.

Dry season maximum incoming solar radiation was slightly above 900 W m^{-2}, net radiation (R_n) reached >400 W m^{-2} during mid day. Maximum latent heat flux (λE) and sensible heat flux (H) during the dry season were 47 W m^{-2} and 360 W m^{-2} respectively. Soil heat flux (G) was >150 W m^{-2} at noon. λE+H were larger than (R_n-G), with an energy balance ratio during the dry season of 1.6, whereas an energy balance ratio <1 is normal [10]. Regression analysis yields (LE+H) = 1.4(R_n-G) – 1.8, r^2 = 0.89. Moist season soil heat flux and soil temperatures were not available. Maximum λE and H during the moist season were 339 m^{-2} W m^{-2} and 236 W m^{-2} respectively.

CO_2 flux data indicates a **neutral or very weak sink during the dry season** and a **stronger sink during the moist season** with slightly lower fluxes when compared to a site in South Africa [1]. This is reasonable as our site is dryer. The location where R_n and G are measured is covered by less vegetation and has more bare soil compared to the flux measurement site, some 300 m apart. This, giving a lower R_n and a higher G, may explain that (λE+H) > (R_n-G).

References

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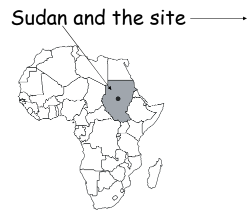
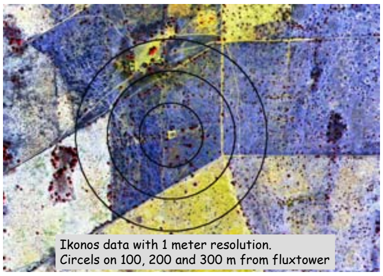
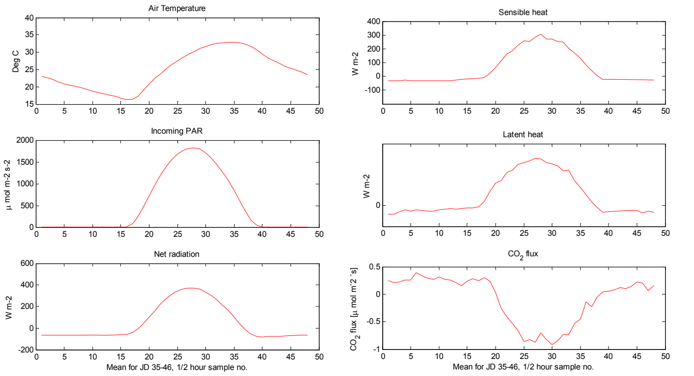
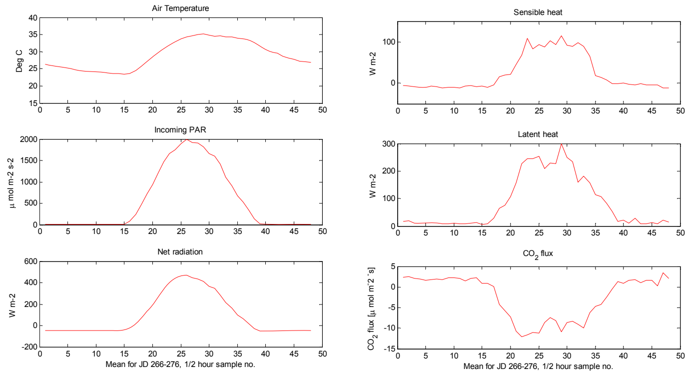




Dry Season — General Data — Wet Season





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