Introduction

High uncertainties remain on Africa’s terrestrial carbon budget, especially on African’s savanna ecosystems.

Models simulating carbon dynamics need site level measurements for calibration and validation. With this goal, the AMMA and CarboAfrica projects had installed few flux towers in Africa, especially in Benin, in the West part of the continent.

Objectives of this study

→ to estimate the net ecosystem exchange of a Sub-Saharan Savanna in Western Africa.
→ to determine some mechanisms and factors that control the daytime and nighttime fluxes in the Savanna.

Methods

- Measurement period: Twenty-one (21) months between August 2007 and April 2009
- \( \text{CO}_2 \) and \( \text{H}_2\text{O} \) fluxes measured with the eddy covariance method.
- Micrometeorological measurements
- Inventory of dominating species around the tower (about 1km×1km).
- All data treated following the EUROFLUX methodology (Aubinet et al., 2000).
- Night time \( \text{CO}_2 \) flux correction: data selection criterion based on \( \sigma_w \) (Acevedo et al., 2008).
- \( \sigma_w \) threshold: 0.12.

Results

- Site description and meteorological conditions of Eddy covariance measurements
- Nighttime \( \text{CO}_2 \) fluxes responses

Figure 1. Site of Eddy Covariance and soil occupation about 1km×1km

- Culture Savanna
- Nalahou village, Donga catchment, Northern part of Benin (450 km NW of Cotonou), West Africa

Figure 2. Mean daily meteorological conditions conditions

- Sudanian climate: One dry season (November to March) and one raining season (April to October)
- Mean annual rainfall: 1200 mm
- Mean annual temperature: 25.3 °C
- Mean daily wind speed: 0.53 m/s to 3.12 m/s
- Inter-tropical zone: 2 maxima et 2 minima PPFD
- After rain, rapid soil moisture decrease
- Winds: mainly SW in wet season, SW and NE in dry season.

Figure 3. Response of net exchange ecosystem (NEE) to PPFD: a) rainy season (August 2008) and b) dry season (January 2008)

- \( \text{CO}_2 \) fluxes responses to PPFD

- Different responses according to the season
- Wet season: \( \text{CO}_2 \) assimilation increases with increasing PPFD following a typical curvilinear function; saturation for PPFD > 1000 µmol m\(^{-2}\) s\(^{-1}\).
- Dry season: Very small response of \( \text{CO}_2 \) flux increases to PPFD due to the small amount of vegetation.

Figure 4. Response of Nighttime net exchange ecosystem to soil moisture during all period

- No clear relation of residuals with either air or soil temperature was observed
- Below \( Sm = 0.1 \) m\(^{-3}\): respiration increases with increasing soil moisture.
- Above \( Sm = 0.1 \) m\(^{-3}\), the respiration response saturates.
- \( \text{CO}_2 \) flux threshold: 0.12.
- Proposed response curve: 

\[
TEC = a \times \left(1 - \exp\left(-b \times (Sm)^2\right)\right)
\]

\(a = 4.2 \text{ µmol m}^{-2} \text{ s}^{-1}\), \(b = 370\), \(R^2 = 0.47\)

Figure 5. Evolution of residuals nighttime net exchange ecosystem (NEE): a) soil temperature and b) air temperature

Main features

- Response to PPFD: Larger \( \text{CO}_2 \) assimilation (up to 25 µmol m\(^{-2}\) s\(^{-1}\)) in wet season due to the importance of vegetation. Practically no response to PPFD in dry season (reduced vegetation, stomatal limitation due to drought).
- Response to soil moisture: Ecosystem respiration remains under the control of soil moisture below 0.1 m\(^{-3}\).
- Response to temperature: No respiration response to temperature: masked by the response to soil moisture? No respiration sensitivity in this temperature range?
- To be continued...

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