DIURNAL CO_2 FLUX RESPONSES IN CULTIVATED SAVANNA IN BENIN (WEST AFRICA)

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1. Introduction

- High uncertainties remain on Africa's terrestrial carbon budget, especially on African's savanna ecosystems.
- Models simulating carbon dynamics need site level data 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.

2. Objectives

→ to estimate the net ecosystem carbon exchange of a Sub-Saharan Savanna in the Western Africa.

→ to determine some mechanisms and factors that control the daytime, nighttime and seasonal fluxes in the African's Savanna

3. Material and methods

Site study

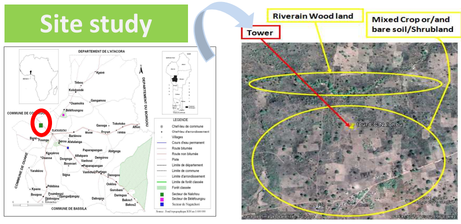


Figure 1. Site study and soil cover about 1kmx1km

- Cultivated Savanna
- Annual Rainfall: 1 200 mm
- Donga catchment
- 9.74°N, 1.60°E, 449 m
- No Herbs in dry season (burned by farmers).
- Slope : 2%.
- Tropical ferruginous soil

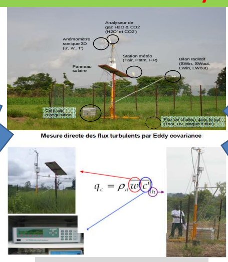
Methods

Continuous Data every 30 mn

Meteorological data

- Precipitation
- Air temperature
- Relative humidity
- Radiation

- **Soil moisture**
- **Soil temperature**



CO_2 and H_2O fluxes :

Eddy covariance method

- Data: Twenty-one (21) months from 4 August 2007 to 15 May 2009
- Sonic at 4.95 m
- Licor 7500

- **Dominating species Inventoried**

$$NEE = Fc + Sc$$

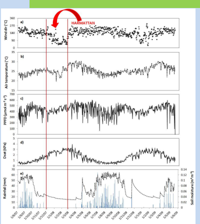
where **Fc** is the eddy covariance flux and **Sc** the storage in the canopy

❑ **All data treated following the EUROFLUX methodology (Aubinet et *al.*, 2000).**

❑ **Night time CO_2 fluxes correction : data selection criterion based on σ_w (Acevedo et *al.*, 2008). The σ_w threshold is 0.12.**

4. Results

- Meteorological conditions



- Sudanian climate : One dry season (November to March) and one rainy season (April to October)
- Mean annual rainfall : 1209 mm
- Mean annual temperature : 25.3 °C
- Inter-tropical zone : 2 maxima et 2 minima PPFD
- After rain, soil moisture decrease rapidly
- Winds: SW about 10 months (mainly in wet season), NE in HARMATTAN (December to January)

Figure 2: Mean daily meteorological conditions

- Diurnal courses of CO_2 fluxes

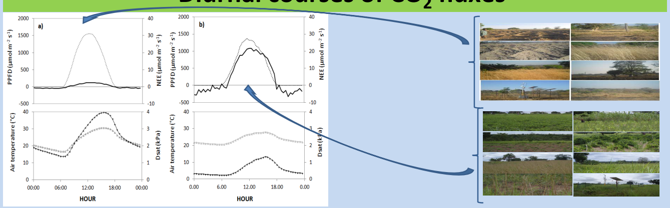
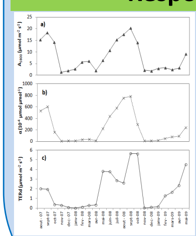


Figure 3. Diurnal course of CO2 net flux (NEE), radiation (PPFD), Air temperature (Tair) and Saturation deficit (Dsat) : a) dry season (January) ; b) wet season (September)

- Different responses according to the season
- **Wet season**: high CO_2 assimilation (max 22 µmol m^{-2} s^{-1})
- **Dry season**: Very small CO_2 assimilation (max 2 µmol m^{-2} s^{-1}) due to the small amount of vegetation.
- Higher Dsat, Tair, PPFD and NEE at noon than early morning and later afternoon
- Very low impact of Dsat and Tair

- Response of daytime CO_2 flux to PPFD



❖ TERd, A_{1800} and α are higher in wet season (5 ; 21 ; 0.08) than dry season (< 1 ; < 3 ; < 0.01)

❖ No impact of Tsol and wind speed

❖ Impact of Hour, wind direction and low of Dsat, Tair,

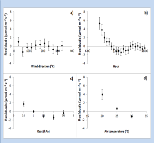


Figure 5: Evolution of residuals of daytime with others factors

Figure 4. Evolution of A_{1800} , quantum light efficiency α and dark respiration TERd

- Nighttime CO_2 fluxes responses to soil moisture

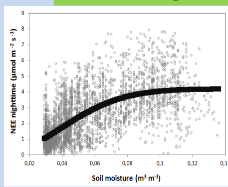
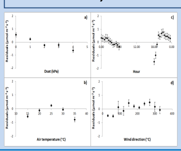


Figure 6. Response of Nighttime NEE to soil moisture considering whole data of period

- Below Sm = 0.1 m^3m^{-3}, respiration increases with increasing soil moisture
- Above Sm = 0.1 m^3m^{-3}, it saturates.
- Proposed response curve: $TER = a(1 - exp(-b(Sm)^2))$

a=TER max=4.2 µmol m^{-2} s^{-1}, b=370 is tied to vegetation increase ; R^2= 0.47 and Sy,x= 1.19



- Very low impact of Hour, Dsat, Tair and Wind direction
- No impact of Tsoil and Wind speed

Figure 7: Evolution of residuals with others factors

5. Main conclusion

❑ **Response to PPFD**: PPFD controls daily variation of CO_2 assimilation

❑ **Response to season**: Water controls mainly the ecosystem dynamics at seasonal scale, assimilation being very small (< 3 µmol m^{-2} s^{-1}) in dry season and going up to 22 µmol m^{-2} s^{-1} in the wet season.

❑ **Impact** : Very low impact of saturation deficit and temperature was found on CO_2 flux neither in dry nor in wet seasons.

❑ **Time of the day** : An asymmetry in the flux response to PPFD was found that cannot be explained by the classical flux response to meteorological conditions.

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