Diurnal and seasonal variability of CO_2 fluxes over a degraded Woodland under a Sudanian climate in Northern Benin, West Africa

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Introduction

High uncertainties remain on Africa's terrestrial carbon budget, especially on African's Woodlands and Forests.

Models simulating carbon dynamics in terrestrial ecosystems need site level measurements for calibration and validation. With this goal, the AMMA-CATCH International program had installed few flux towers in West Africa, especially in Benin.

Objectives of this study

→ to estimate the net ecosystem exchange and their major components of a Sub-Saharan Woodland in Western Africa.

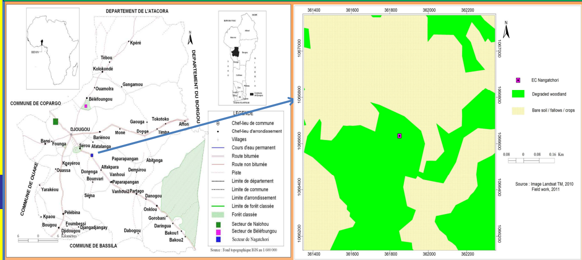
→ to determine some mechanisms and factors that control the daytime and nighttime fluxes in the Woodland.

Methods

- Measurement period : Seventeen (17) months between November 2005 and March 2007
- CO_2 and H_2O fluxes measured by eddy-covariance method.
- Micrometeorological measurements & dominating species inventory around the fluxes tower (1kmx1km).
- All data treated following standard methodology (Aubinet et al., 2012).
- Nighttime CO2 flux correction, u* threshold 0.10 as found by (Ago et al., 2014).
- Daytime gaps were filled using the Misterlich equation and Nighttime gaps using the relationship with the daily means of relative humidity (RH)
-Flux-partitioning was performed into Gp and R, the two main components (Gilmanov et al., 2013, 2010)

Results

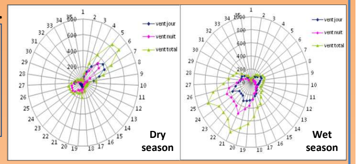
Site description and meteorological conditions of Eddy covariance measurements

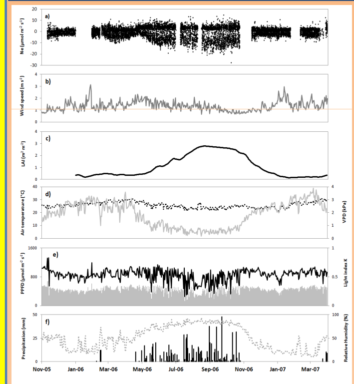


- Degraded Woodland
- in Benin, they occupy 2/3 of total dense forest area (Sokpon et al., 2006)
- village of Nangatchori, Djougou district in Benin (West Africa)
- 9.65°N, 1.74° E, 432 m alt

Figure 1. Location of site and land use on 1km² around the flux tower.

- Site location : "*Northern savanna belt*".
- Vegetation : Woodland, Fallow and Crop.
- No Herbaceous in dry season (burned by farmers).
- Soil type : tropical ferruginous soil dominates.





- Sudanian climate: One dry season (December to March), one wet season (June to September) and two transitional seasons (October-November and April-May)
- 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
- Winds: mainly SW (wet season), NE (dry season).

Figure 2. Mean daily meteorological conditions at the Djougou region and CO_2 fluxes overview.

Diurnal course of CO_2 fluxes and response to radiation (Q_p)

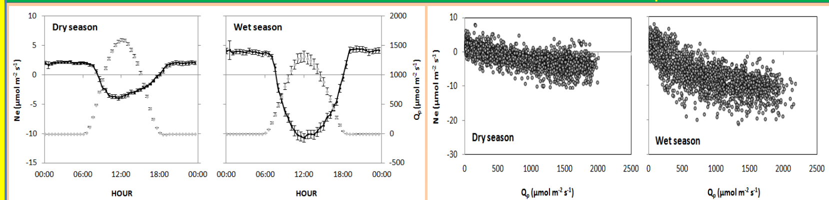
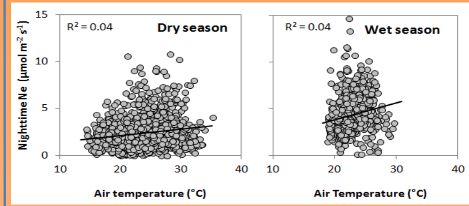


Figure 3. Diurnal course of net exchange ecosystem (Ne) and response to radiation. The error bars represent 95 % confidence interval.

- Different responses according to the season: in **wet season**, CO_2 assimilation increases with radiation increasing (Q_p) following a typical curvilinear function while in **dry season**, very small response of CO_2 flux increases to Q_p due to the small density of green vegetation.
- Saturation was observed for Q_p > 1000 µmol $m^{-2}s^{-1}$

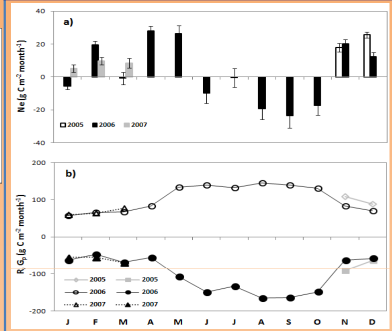
Nighttime CO_2 fluxes response to temperature



No clear dependence of ecosystem respiration on the temperature was observed.

Figure 4. Relationship between Nighttime net exchange ecosystem (Ne) and temperature .

Seasonal variability of carbon fluxes



- A strong seasonal variability was observed.
- Carbon sink (dry season) and source (wet season).
- During dry season, Ecosystem respiration (R) and Gross primary productivity (Gp) were reduced.
- At annual scale (during 2006), the site was near of the equilibrium with the cumulated Ne equal to 29 ± 16 g C m^{-2}.

Figure 5. Evolution of monthly cumulated values of carbon fluxes. The error bars represent 95 % confidence interval.

Discussion and main conclusions

❑ **Response to radiation**: Larger CO_2 assimilation (up to 20 µmol m^{-2} s^{-1}) in wet season due to the importance of green vegetation. Practically, a very small response to radiation was found in dry season (reduced green leaves, stomatal limitation due to the drought).

❑ **Response to temperature**: No clear respiration response to temperature was found probably because it was masked by the response to soil moisture or the respiration was insensitive to the temperature range at this region?

❑ **Seasonal variability**: A strong variability of carbon fluxes were observed due to the alternation between dry and wet seasons.

❑ **Annual pattern** : The site was near the equilibrium concerning the carbon exchanges with the atmosphere probably due to the high disturbance by local populations through the agricultural activities, fire, gazing and illegal trees logging.

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