Carbon fluxes over two contrasting types of vegetation in West Africa: the case of Forest and Savannah sites under Sudanian climate in northern Benin

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Introduction

Africa is a sink of carbon, but high uncertainties remain on the carbon budget for many African ecosystems, such as the Savannah and Forests.

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

Objectives of this study

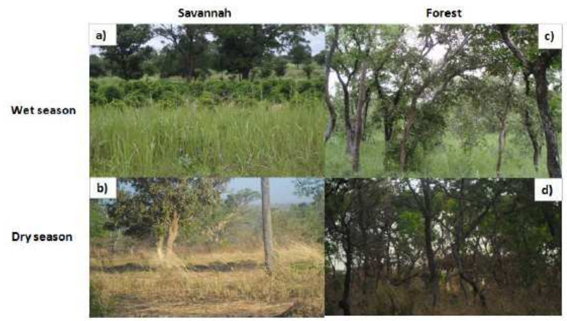
→ to estimate the net ecosystem exchange and their major components of West African sites.

→ to determine some mechanisms that control the daytime and nighttime fluxes in both Savannah and Forests.

Methods

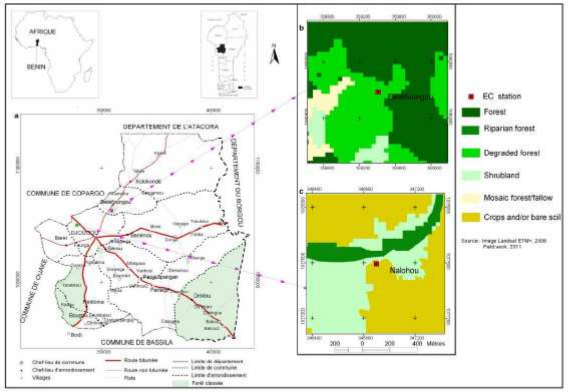
- Measurement period : Sixteen (16) months between July 2008 and December 2009
- CO_2 and H_2O fluxes measured by an eddy-covariance system
- Micrometeorological measurements & dominating species inventory around the fluxes tower (1kmx1km).
- All data was analyzed and treated following the standard methodology (Aubinet et al., 2012).

- Nighttime CO2 flux correction, u* threshold of 0.10 m s^{-1} was found by a visual approach (Ago et al., 2014, 2015).
- Daytime gaps were filled using the Misterlich equation and Nighttime gaps using the sigmoïdal equation between noctural flux and soil water content (SWC)
-Flux-partitioning was performed into Gp and R, which are the two main components (Reichstein et al., 2005)



Results

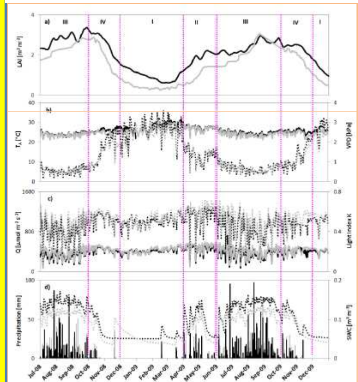
Sites description and meteorological conditions of Eddy covariance measurements



- 9.79°N, 1.72° E, 414 m alt
- 9.74°N, 1.60° E, 449 m alt

- Site location : "*Northern savanna belt*".
- Vegetation : forest, crop and Fallow.
- No annual herbs in dry season (burned by farmer).
- Soil type : tropical ferruginous soil dominates.

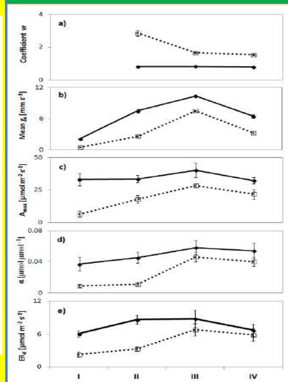
Figure 1. Location of two sites and land use on 1km² around the flux tower.



- Sudanian climate: One dry season (December to March), one wet season (June to September) and two transitional periods (October-November and April-May)
- mean annual rainfall: 1200 mm and Ta : 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 two sites located at the Djougou region and four period defined.

Seasonal courses of CO_2 fluxes and parameters characterizing two ecosystems



- Different values of CO2 fluxes according to the season: due mainly to the density of green vegetation.
- Larger assimilation and respiration during wet periods
- CO2 fluxes were always higher at forest than savannah within each period

Figure 3 Seasonal courses of parameters characterizing two sites during four periods : (a) coefficient w describing the WUE sensitivity to VPD, (b) mean canopy conductance (g_c), (c) A_{max}, NEE at light saturation, (d) α, quantum efficiency and (e) ER_d, dark respiration. Savannah (dark discontinuous line) and Forest (dark continuous line). Error bars are 95 % confidence interval.

Response of the ecosystem respiration to temperature and soil water content (swc)

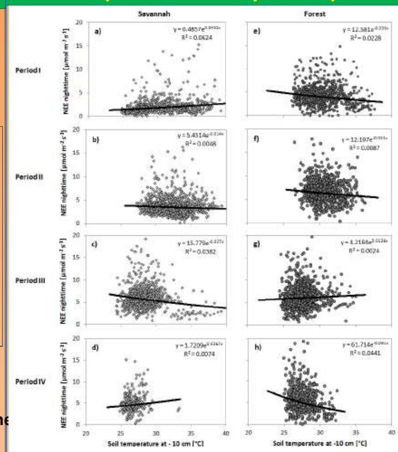


Figure 4 Relationships between nighttime NEE and soil temperature at 10 cm depth at two sites during periods I to IV: Savannah (a-d) and Forest (e-h). Data were filtered

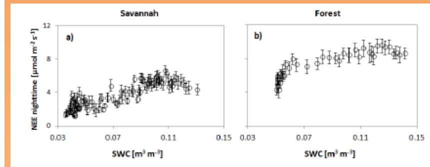


Figure 5 Relationships between nighttime NEE and soil water content at 10 cm depth at two sites: Savannah (a) and Forest (b). Filtered data were used. Data points are bin averages of 25 measurements. Error bars are 95 % confidence interval.

- No clear dependence of respiration on soil temperature was observed.
- Clear dependency of respiration on the soil water content

Seasonal cumulated net exchange ecosystem (NEE)

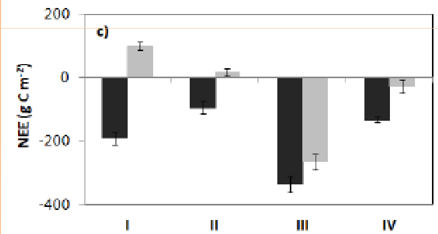


Figure 6 Seasonal cumulated NEE during periods I to IV of two ecosystems : Savannah (grey color) and Forest (dark color). Error bars are 95 % confidence interval

- Forest acted always as C sink
- Savannah was C source during periods I and II , and C Sink during III and IV.
- At annual scale, Forest sequestered 0.64 ± 0.05 and Savannah 0.19 ± 0.04 kg C m^{-2}.

Discussion and main conclusions

❑ **Response to season**: Larger CO_2 fluxes in wet season due to the importance of green vegetation. Practically, a very low canopy conductance 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?

❑ **Annual patterns** : Two sites were nets sinks carbon during the measurement period.

Acknowledgements

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