UNRAVELING THE ROLE OF BRAZILIAN SEASONALLY DRY TROPICAL FOREST (CAATINGA) ON CO_2, ENERGY AND WATER EXCHANGES

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Le rôle de la forêt tropicale sèche brésilienne (Caatinga) dans les échanges de CO_2, d'eau et d'énergie

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Keywords: eddy covariance, climate change, carbon sink

Introduction

In a climate change context, it is crucial to better understand the role of ecosystems in regional and global carbon and energy balances. Highly productive ecosystems, such as the Amazon Forest and other rainforests worldwide, usually act as carbon sinks, absorbing carbon from the atmosphere. However, these lands suffer from deforestation and climate change itself, and recently have behaved as carbon sources (Gatti *et al.,* 2021). However, dryland ecosystems, which cover 45% of Earth's surface, have been reported to be controlling observed trends in global carbon balance (Mendes *et al.,* 2020). Seasonally dry tropical forests, for example, feature extremely high carbon and water use efficiency, mainly due to moderate annual gross primary production (GPP) rates associated with low respiration rates, acting as carbon sinks even in extreme scenarios.

In Brazil, the Caatinga ('white forest' in native indigenous language) dry forest occupies 11% of the national territory and hosts a highly biodiverse and endemic ecosystem, which provide resources for the most populated semiarid land in the world. Nevertheless, it has been suffering for decades from the lack of specific conservation policies, poor agricultural management practices, and scarce environmental monitoring (Mendes *et al.,* 2021). In this context, the Research Group for Observational and Modelling Studies on the Biosphere-Atmosphere Interactions (GEOMA) is one of the pioneering and leading groups conducting research focused on understanding the role of the Caatinga forest in the carbon and energy balance. The group is supported by the National Observatory of Water and Carbon Dynamics in the Caatinga Biome (NOWCDCB - https://www.ondacbc.com.br/redes?lang=fr) and aims to understand in which conditions the Caatinga behave as a carbon sink or source (Mendes *et al.,* 2020), how the environment controls water and energy fluxes on the biome (Marques *et al.,* 2020), how the forest use energy in its biophysical activities (Campos *et al.,* 2019), how rainfall influences on energy, water and carbon fluxes in the Caatinga (Santos e Silva *et al.,* 2024), how can we improve the Caatinga representation in ecological and land models (Mendes *et al.,* 2021), among other goals.

The objective of this communication is to briefly summarize the main results found by the GEOMA group and the NOWCDCB for a particular fragment of preserved Caatinga (mostly xerophytes and deciduous species lower than seven meters, sparsely distributed with shrubs and herb patches) located in the Seridó Ecological Station (ESEC-Seridó), Rio Grande do Norte, Northeast Brazil. Results were generated using two years (2014-2015) of high and low frequency data measured in a flux tower equipped with an eddy covariance system owned by the National Institute for the Semiarid (INSA). Measured variables included carbon and water fluxes, temperature, humidity, wind, net radiation and albedo.

1. Energy exchanges

Energy partitioning in the Caatinga is highly dependent on rainfall seasonality, with approximately 70% of net radiation (Rn) being converted into sensible heat flux (H) and roughly 5% into latent heat flux (LE) during the dry season. In the wet season, however, both fluxes account for approximately 40%. Water scarcity greatly reduces LE in the dry season, since plants are usually dormant and stomates are closed to prevent further water loss. In rainforests, this behavior is not observed since evaporation is limited by the dense canopies.

2. Water exchanges

In the Caatinga, higher atmospheric demand for water did not necessarily lead to an immediate increase in actual evapotranspiration (ET). Annual ET was of 473 mm in 2014 (513 mm concentrated annual precipitation), but only 283 mm in 2015 (466 mm distributed precipitation), while surface conductance was also lower in 2015. Seasonally, high vapor pressure deficit did not lead to increasing ET, since it was controlled by surface conductance and the biophysical behavior of Caatinga and semiarid plants, which will reduce water loss via stomatal closure in the transition and dry seasons despite atmospheric demands for water.

3. CO_2 exchanges

Despite 2014 and 2015 being drier-than-average years, the Caatinga still acted as a carbon sink in both years (-626 and -538 g C m^{-2} y^{-1}), due to low respiration rates and highly-efficient carbon-use. In fact, the balance was comparable and even better than results found in tropical rainforests, even the Amazon, which struggle with high respiration rates (carbon loss). Rainfall pulses also proved to greatly influence on CO_2 absorption, with up to 68% of total carbon uptake happening after rain pulses.

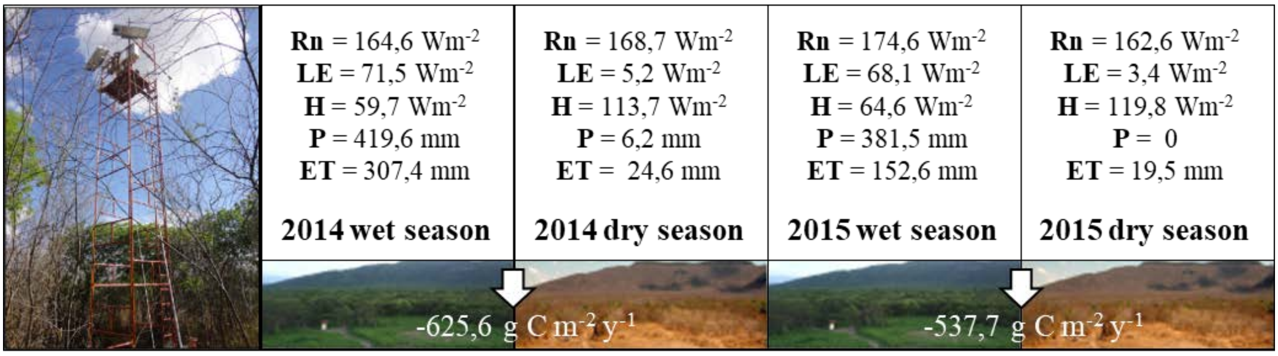

Figure 1. Summary of main results of the Caatinga role on energy, water and carbon exchanges.
Rn: net radiation; LE: latent heat flux; H: sensible heat flux; P: precipitation; ET: actual evapotranspiration

Conclusion

So far, results indicate that the Caatinga is an extremely efficient ecosystem regarding water and carbon use, even during dry years. It acted as a carbon sink under below-average rainfall conditions. We urge for attention and more investments to research on this extremely important biome, with the potential to contribute to climate change mitigation by providing high carbon fixation among other ecosystem services explored by other fields.

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