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Artigos

Effects of deforestation on microclimate in a Cerrado-Amazonia Transition area

Efeitos do desmatamento no microclima em uma área de Transição Cerrado-Amazônia

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ABSTRACT

The Cerrado-Amazon Transition region has a high deforested area in Brazil. Given the importance of the forest in maintaining the climate of this region, were evaluated the patterns of micrometeorological variables in forested and deforested areas in the Cerrado-Amazon Transition region in Mato Grosso, Brazil. Precipitation, solar radiation, average, minimum and maximum air temperature, relative air humidity, soil temperature and wind speed were measured into a forest (FOR) and in a deforested area (DEF). Precipitation in the studied region has a hyper-seasonal pattern with 95% of the volume in the wet season (October to April), which influenced the seasonality of the micrometeorological variables. Solar radiation in DEF was 8-folds higher than in FOR, air temperature in DEF was up to 11% higher than in FOR, relative humidity in FOR was up to 14% higher than in DEF, soil temperature in DEF was 18% greater than in FOR and wind speed in DEF was 22-folds greater than in FOR. Deforestation significantly influenced the seasonality and magnitude of the analyzed micrometeorological variables.

Keywords: Amazon Basin; Cerrado; Climate change; Deforestation; Microclimate

RESUMO

A região de Transição Cerrado-Amazônia possui uma elevada área desmatada no Brasil. Dada a importância da floresta na manutenção do clima desta região, foram avaliados os padrões de variáveis micrometeorológicas em áreas florestadas e desmatadas na região de Transição Cerrado-Amazônia em Mato Grosso, Brasil. A precipitação, radiação solar, temperatura média, mínima e máxima do ar, umidade relativa do ar, temperatura do solo e velocidade do vento foram medidas no interior de uma floresta (FOR) e em uma área desmatada (DEF). A precipitação na região estudada apresenta um padrão hipersazonal com 95% do volume na estação chuvosa (outubro a abril), o que influenciou na sazonalidade das variáveis micrometeorológicas. A radiação solar em DEF foi 8 vezes maior que em FOR, a temperatura do ar em DEF foi até 11% maior que em FOR, a umidade relativa em FOR foi até 14% maior que em DEF, a temperatura do solo em DEF foi 18% maior que em FOR e a velocidade do vento em DEF foi 22 vezes maior do que em FOR. O desmatamento influenciou significativamente a sazonalidade e magnitude das variáveis micrometeorológicas analisadas.

Palavras-chave: Bacia Amazônica; Cerrado; Alterações climáticas; Desmatamento; Microclima

1 INTRODUCTION

The Cerrado-Amazonia Transition (CAT), an extensive transitional region (> 6,000 km) located between the two largest biogeographic domains of South America, is by far the largest savanna-forest transition on the planet, separating the Cerrado (the greatest and most diverse savana) from Amazonia (the most extensive tropical forest worldwide) (MARQUES; MARIMON-JUNIOR; MARIMON; MATRICARDI; MEWS; COLLI, 2020). CAT is characterized by a highly seasonal climate, nutrient-carbon hypercycling and vegetation hyperdynamics (ALVARES; STAPE; SENTELHAS; GONÇALVES; SPAROVEK, 2013). CAT is also an agricultural frontier, known as the "Arc of Deforestation", owing to its rapid and continuous conversion of natural areas into agricultural systems and pastures and to selective timber logging and forest fires (FEARNSIDE, 2018).

Changes in vegetation are known to have an impact on climate via biogeochemical exchanges that change the chemical composition of the atmosphere and via biogeophysical properties that influence energy balance and exchange at the land surface (STRANDBERG; KJELLSTRÖM, 2019). Although, the net impact of these biogeochemical and biogeophysical effects depends strongly upon forest latitude: tropical deforestation is generally found to warm the climate whereas high latitude deforestation is generally found to cool the climate (LI; ZHAO; MOTESHARREI; MU; KALNAY; LI, 2015). Flux towers, ground-based and satellite observations indicate that tropical deforestation results in warmer, drier conditions at the local scale. In general, afforestation leads to more evapotranspiration (ET), which leads to decreased near-surface temperature, whereas deforestation leads to less ET, which leads to increased temperature (STRANDBERG; KJELLSTRÖM, 2019).

Forest microclimates contrast strongly with the climate outside forests such as open habitats. Vegetation density (canopy cover, basal area, or plant area index) via effects on albedo, evapotranspiration and radiation absorption have strong influences on understory microclimate (BIUDES; MACHADO; DANELICHEN; SOUZA; VOURLITIS; NOGUEIRA, 2014a). For example, below forest canopies, direct sunlight and wind speed are strongly reduced, leading to a dampening of temperature and humidity variations (BIUDES; MACHADO; DANELICHEN; SOUZA; VOURLITIS; NOGUEIRA, 2014a). On the other hand, deforestation changes rainfall interception, albedo and net radiation, turbulent transport, leaf area and canopy resistance, rooting depth and plant-available water, leading to an evapotranspiration decrease (IVO; BIUDES; VOURLITIS; MACHADO; MARTIM, 2020). Furthermore, microclimates strongly influence soil decomposition, primary productivity, plant communities and forest density, which further influences groundwater and carbon sequestration via its influence on soil dynamics (BIUDES; SOUZA; MACHADO; DANELICHEN; VOURLITIS; NOGUEIRA, 2014b).

Mato Grosso is one of the states with the greatest agricultural importance in Brazil and represents one of the main agricultural frontiers in the world (LOPES; MOURA; NASCIMENTO; FRAGA JUNIOR; ZOLIN; DUARTE; FOLEGATTI; SANTOS, 2020). In addition, Mato Grosso state covers in its territory Amazon Forest – the largest and most diverse rainforest in the world, Cerrado – the second largest biome in Brazil and has a high rate of endemic plants, and Pantanal – the largest wetland in the world (FEARNSIDE, 2018; KLINK; MACHADO, 2005). In this context, high biodiversity and complex ecological phenomena associated with high rates of deforestation become studies on microclimate changes required. Thus, the goals of this study were (i) to evaluate micrometeorological variables (precipitation, solar radiation, mean air temperature, maximum air temperature, minimum air temperature, soil temperature, relative humidity, and wind speed) into a forested (FOR) and deforested (DEF) areas in the CAT in Mato Grosso state in 2012 and 2013; (ii) to assess seasonality and hourly variation of the micrometeorological variables into a forested (FOR) and deforested (DEF) areas; and (iii) to correlate meteorological variables with each other for forested (FOR) and deforested (DEF) areas.

2 MATERIAL AND METHODS

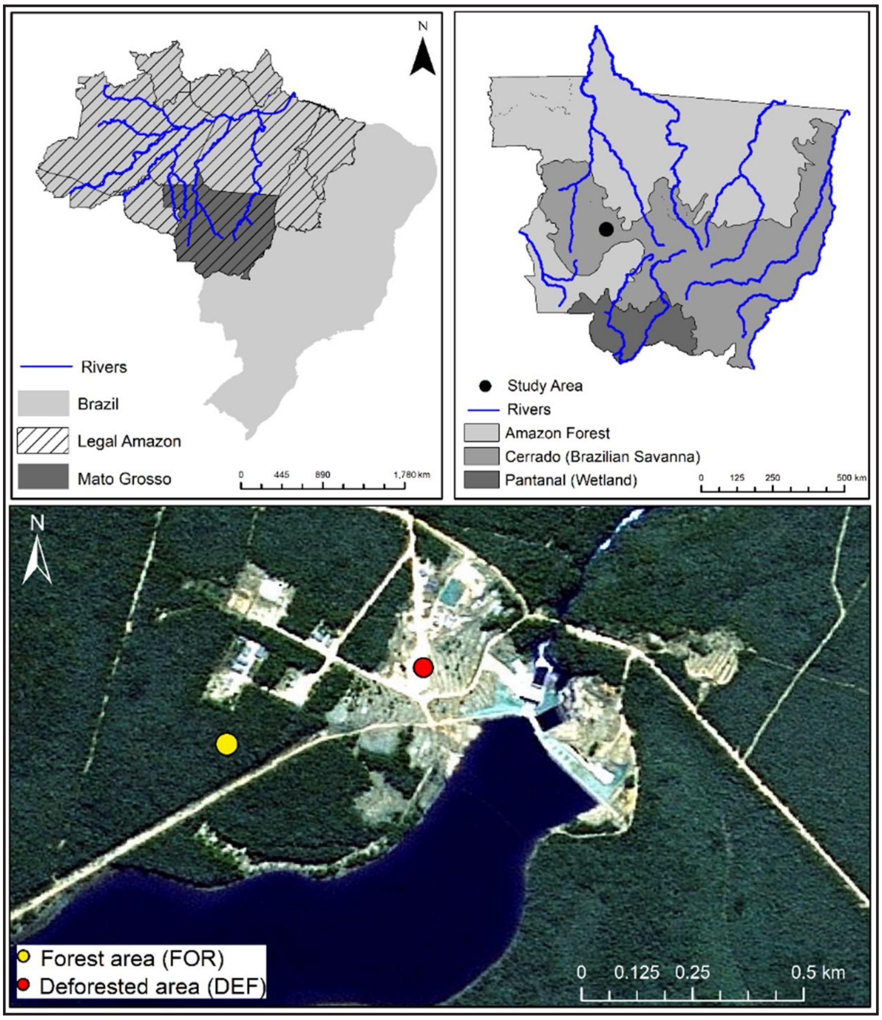
2.1 Study area

This study was conducted in two distinct areas, inside a forested Cerrado-Amazon ecotone (FOR) and in the deforested area (DEF) (Figure 1). The study area is located on a small hydropower plant 50 km NE of the city of Campo Novo do Parecis in the Southern Amazon Basin (13º19’ S: 57º36’ W). The landform is flat with sandy soil. The surrounding area is composed of pasture and agricultural areas. The regional climate is Aw, according to Köppen classification (ALVARES; STAPE; SENTELHAS; GONÇALVES; SPAROVEK, 2013), with a wet season from October to April and a dry season from May to September (BIUDES; VOURLITIS; MACHADO; ARRUDA; NEVES; LOBO; NEALE; NOGUEIRA, 2015).

2.2 Micrometeorological measurements

A micrometeorological station in each experimental area continuously measured the solar radiation (Rg), air temperature (Tair), relative humidity (RH), soil temperature (Tsoil), wind speed (WS) and rainfall. Sensors and data acquisition were identical at both sites, and a full list, including instrument model and installation information, is provided in Table 1. The variables were recorded in a datalogger (U30-NRC, Onset Computer Corporation, Bourne, MA, USA) connected to a battery-powered by a solar panel (10 W).

Figure 1 – Location of the forested (FOR) and the deforested areas (DEF) in the Cerrado-Amazonia Transition in Mato Grosso, Brazil



Source: Authors (2022)

2.3 Statistical analysis

The Confidence Interval (CI) was calculated by Bootstrap over 1000 iterations (TIBSHIRANI; EFRON, 1993) to verify the difference between the annual and seasonal means of variables. Spearman's statistical coefficient is a nonparametric measure of rank correlation. It was used to assess how well the relationship was between micrometeorological variables considering dry and wet seasons both in a forested area (FOR) and in a deforested area (DEF). Statistical analyzes were performed in R Program.

Table 1 – Description of the equipment used to measure areas in the Cerrado - Amazonia Transition in Mato Grosso, Brazil

Variable	Equipment Description	Height (m)	
		FOR	DEF
Precipitation (Ppt)	S-RGB-M002, Onset Computer Co., Bourne, MA, USA	–	2.5
Solar radiation (Rg)	S-LIB-M003, Onset Computer Co., Bourne, MA, USA	2.5	2.5
Air temperature (Tair)	S-THB-M002, Onset Computer Co., Bourne, MA, USA	2.0	2.0
Relative humidity (RH)	S-THB-M002, Onset Computer Co., Bourne, MA, USA	2.0	2.0
Soil temperature (Tsoil)	S-TMB-M002, Onset Computer Co., Bourne, MA, USA	0.1	0.1
Wind speed (Ws)	S-WCA-M003, Onset Computer Co., Bourne, MA, USA	2.0	2.0

Source: Authors (2022)

In where: solar radiation (Rg); air temperature (Tair); relative humidity (RH); soil temperature (Tsoil); wind speed (WS); precipitation (PPT); forested (FOR); deforested (DEF)

3 RESULTS AND DISCUSSION

The average annual precipitation (ppt) was 1832.2 mm in the study area. The ppt was 40% higher in 2013 than in 2012 (Table 2) and was affected by seasons. The ppt during the wet season was approximately 95% of the total annual precipitation. Monthly ppt was higher in January and decreased into May (Figure 2A), which marked the beginning of the dry season, i.e., duration in which total monthly rainfall is lower than 100 mm (BIUDES; VOURLITIS; MACHADO; ARRUDA; NEVES; LOBO; NEALE; NOGUEIRA, 2015). Although dry season duration was five months in both years, it occurred from June to October in 2012 and from May to September in 2013. Seasonal variations in precipitation were consistent with the climatology for the region (BIUDES; VOURLITIS; MACHADO; ARRUDA; NEVES; LOBO; NEALE; NOGUEIRA, 2015). Delays or advances in precipitation season are often partitioned into two components. One is related to a thermodynamic component resulting from increased atmospheric water vapor. Other is related to a dynamic component associated with changes to the atmospheric circulation (SEAGER; NAIK; VECCHI, 2010).

Table 2 - Areas in the Cerrado-Amazonia Transition in Mato Grosso, Brazil during the annual and wet and dry season

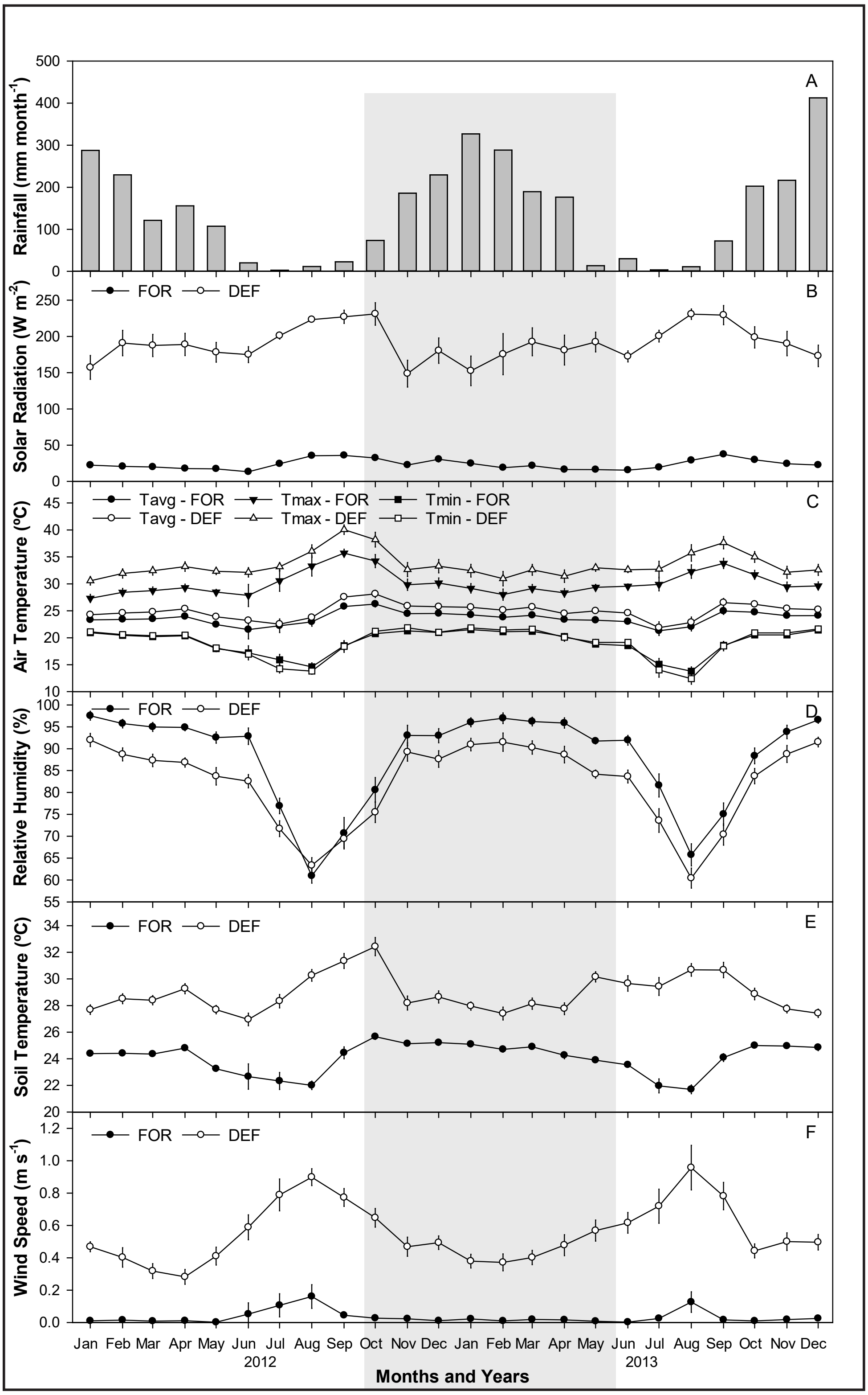
Site	Variable	2012			2013		
		Annual	Wet	Dry	Annual	Wet	Dry
Forest (FOR)	Ppt	-	-	-	-	-	-
	Rg	24.5±1.1	21.6±1.1	32.1±2.0	23.1±1.0	22.8±1.3	23.5±1.5
	Tair	24.1±0.2	23.7±0.2	25.2±0.5	23.6±0.2	24.1±0.1	22.9±0.3
	Tmax	30.3±0.4	28.9±0.3	34.0±0.7	30.0±0.3	29.4±0.4	31.0±0.5
	Tmin	19.9±0.2	20.3±0.2	18.8±0.6	19.3±0.3	20.9±0.1	16.9±0.4
	RU	89.4±1.3	94.5±0.5	75.6±2.7	89.1±1.1	94.8±0.6	81.2±1.9
	Tsoil	24.5±0.1	24.5±0.1	24.4±0.4	24.1±0.1	24.8±0.1	23.0±0.2
	Ws	0.0±0.0	0.0±0.0	0.1±0.0	0.0±0.0	0.0±0.0	0.0±0.0
Deforested (DEF)	Ppt	1525.81	1468.71	57.10	2138.68	2030.27	108.41
	Rg	183.9±5.1	176.3±6.4	201.6±6.7	192.1±5.0	182.2±7.9	205.1±5.5
	Tair	25.0±0.2	24.9±0.2	25.1±0.5	24.9±0.2	25.4±0.2	24.1±0.4
	Tmax	33.8±0.4	32.3±0.4	36.0±0.7	33.3±0.4	32.5±0.4	34.3±0.6
	Tmin	19.1±0.3	20.5±0.2	17.1±0.6	19.3±0.4	21.2±0.2	16.6±0.6
	RU	84.1±1.0	87.9±0.7	74.8±1.6	83.1±1.1	89.3±0.7	74.4±1.7
	Tsoil	28.5±0.2	28.3±0.2	29.0±0.5	28.8±0.2	27.9±0.1	30.1±0.2
	Ws	0.5±0.0	0.4±0.0	0.7±0.1	0.6±0.0	0.4±0.0	0.7±0.0

Source: Authors (2022)

In where: Total precipitation (Ppt; mm); solar radiation (Rg; W m^{-2}); air temperature (Tair; °C); maximum air temperature (Tmax; °C); minimum air temperature (Tmin; °C); soil temperature (Tsoil; °C); relative humidity (RU; %); wind speed (Ws; m s^{-1}); forested (FOR); deforested (DEF)

The solar radiation (Rg) in DEF was around 8-fold higher than into FOR (Table 2). There was a significant effect of season on Rg in both sites, with higher values in the end of the dry season. The Rg in DEF had a negative correlation with Ppt (Figure 5), but there was no correlation between Rg and Ppt into FOR (Figure 4). The highest Rg into FOR was in September, and the lowest one was in June, while the highest Rg in DEF was in October, and the lowest one was in January (Figure 2B). The hourly pattern of Rg was different between sites and between stations (Figure 3A and 3B). The Rg maximum occurred near 12h, and values greater than 5 W m^{-2} at 6 am in the wet season, and 7 am in the dry season in both sites. The maximum values of Rg higher in the dry season at both sites. The maximum value of Rg in DEF was approximately 6-fold higher than into FOR.

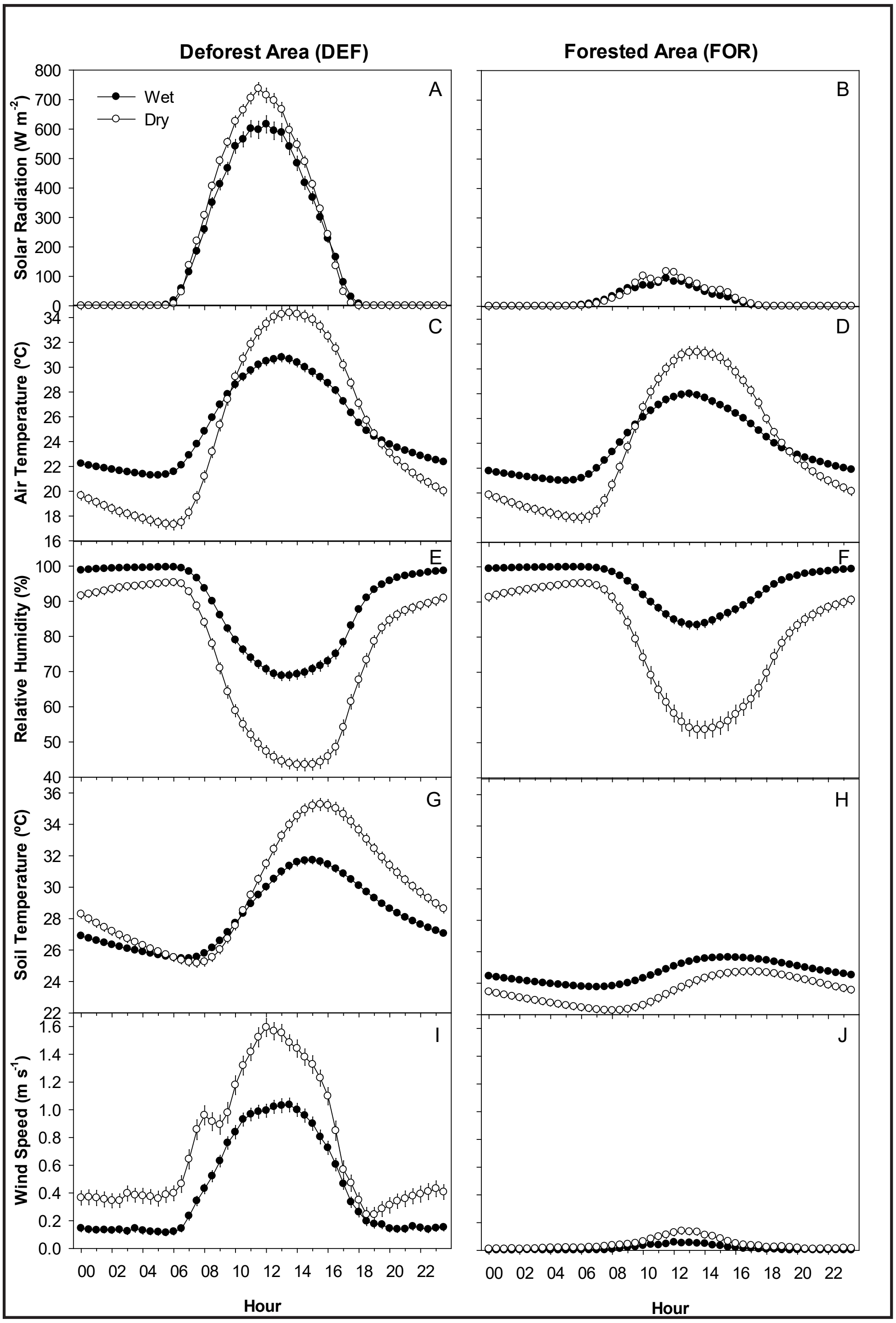
Figure 2 – Areas in the Cerrado-Amazonia Transition in Mato Grosso, Brazil



Source: Authors (2022)

In where: Total monthly precipitation (A); solar radiation (B); air temperature (C); air relative humidity (D); soil temperature (E); wind speed (F); forested (FOR); deforested (DEF); *The shaded portion in each figure depicts the dry season.

Figure 3 – Seasonal mean hourly (±95% Confidence Interval) areas in the Cerrado-Amazonia Transition in Mato Grosso, Brazil



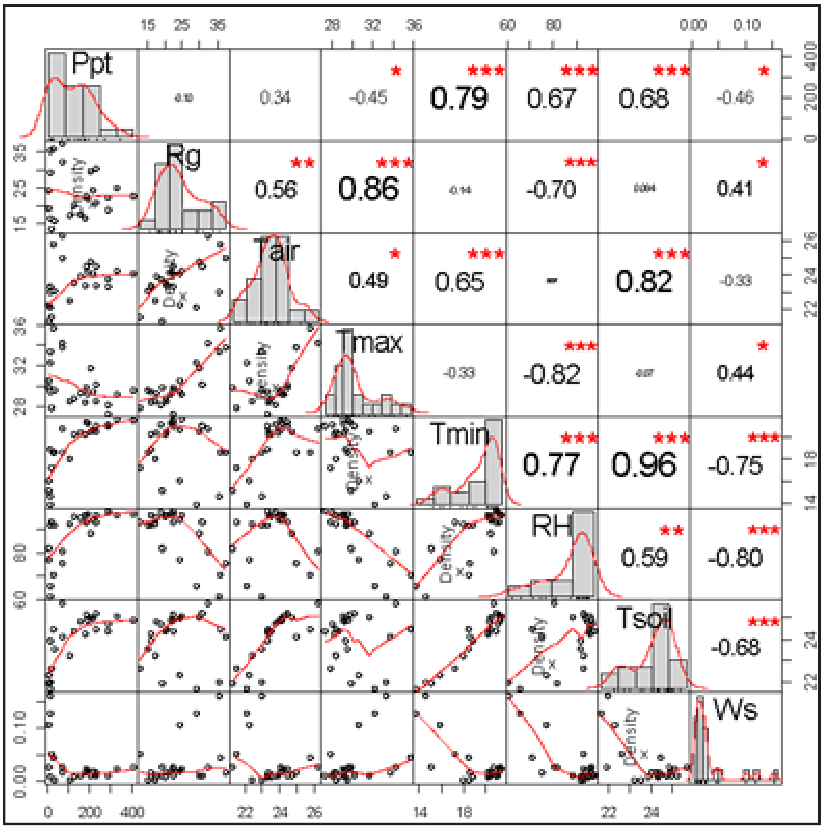
Source: Authors (2022)

In where: A and B, solar radiation (W m^{-2}); C and D, air temperature (ºC); E and F, relative humidity (%); G and H, soil temperature (ºC); I and J, wind speed (m s^{-1}); deforested (DEF); forested (FOR); *Black circles represent the wet season, and white circles represent the dry season in the sites under analysis.

Solar radiation reaching the Earth's surface plays an important role in the energy balances of numerous physical, chemical, and biological processes (YUAN; ZHU; ZHENG; ZHAO; CHEN; RILEY; CAI; MA; LI; WU; CHEN, 2021). The changes in the amount of solar radiation greatly influences the terrestrial ecological ecosystems and the climate (ELLISON; MORRIS; LOCATELLI; SHEIL; COHEN; MURDIYARSO; GUTIERREZ; NOORDWIJK; CREED; POKORNY; GAVEAU; SPRACKLEN; TOBELLA; ILSTEDT; TEULING; GEBREHIWOT; SANDS; MUYS; VERBIST; SPRINGGAY; SULLIVAN, 2017). In general, cloudiness during the wet season causes a decline in incident solar radiation at low latitudes and biomass-burning aerosols during dry season can reduce the amount of incoming solar radiation to the land surface. Thus, the highest values of Rg that occurred in the transition between the dry and wet season were probably due to the combined effect of the astronomical factor, observed by the negative declination, and the occurrence of the first rains of the wet season in the study area, which reduce atmospheric aerosols (LIU; CHENG; WANG; WEI; PÖHLKER; PÖHLKER; ARTAXO; SHRIVASTAVA; ANDREAE; PÖSCHL; SU, 2020). Thus, this transitional period is characterized by an incidence of more abundant direct radiation, and consequently, with less diffuse radiation (ZAMADEI; SOUZA; ALMEIDA; ESCOBEDO, 2021).

The diurnal variation in the incidence of solar radiation can be understood by the solar cycle together with the effects of the seasons. In a forest, the diurnal variation of radiation reaching the soil is directly related to the spatial arrangement of leaves, leaf insertion angle, leaf area index and optical properties of the vegetation (BIUDES; MACHADO; DANELICHEN; SOUZA,; VOURLITIS; NOGUEIRA, 2014a). The radiation, when intercepted by the canopy, can be absorbed, transmitted, and reflected in variable proportions, depending on the angle of incidence of the sun's rays and the structural characteristics of the plants (YUAN; ZHU; ZHENG; ZHAO; CHEN; RILEY; CAI; MA; LI; WU; CHEN, 2021). Vegetation can minimize the effects of the radiation incidence through interception; however, it depends on factors such as the density of the canopy cover. In the dry season, there is a higher incidence of solar radiation in the forest floor due to reduction of tree cover as consequence of leaf loss (HERNANDES; PEDRO JÚNIOR; BARDIN, 2004). The formation of clearings in the forest canopy also causes changes in climatic conditions inside the forest (BIUDES; MACHADO; DANELICHEN; SOUZA; VOURLITIS; NOGUEIRA, 2014a).

Figure 4 – Cerrado-Amazonia Transition in Mato Grosso, Brazil

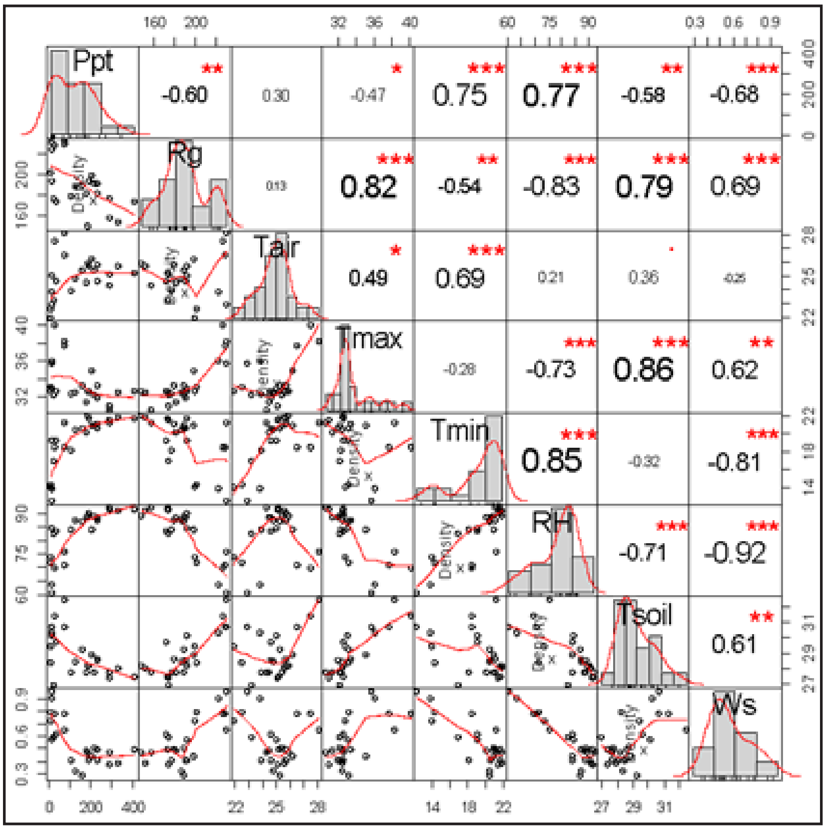


Source: Authors (2022)

In where: Correlogram of precipitation (Ppt; mm); solar radiation (Rg; W m^{-2}); average air temperature (Tair; °C); maximum air temperature (Tmax; °C); minimum air temperature (Tmin; °C); relative humidity (RU; %); soil temperature (Tsoil; °C); wind speed (Ws; m s^{-1}); forested area (FOR).

The mean air temperature (Tair) did not correlate with ppt in both sites and with Rg in DEF, but the Tair into FOR had a positive correlation with Rg (Figures 4 and 5). The maximum air temperature (Tmax) was negatively correlated, and the minimum air temperature (Tmin) was positively correlated with ppt in both. The Tmax in both sites had a strong positive correlation with Rg, while just the Tmin in DEF had a moderate negative correlation with Rg. The Tair in DEF was 5% higher than in FOR (Table 2). Tair varied seasonally and annually, with higher values during the dry season in 2012 and lower values in 2013 than the wet season in both sites (Figure 2C). The Tmax in DEF was 11% higher than FOR. Tmax varied seasonally with higher values in the dry season in both sites. The Tmin in FOR was 2% higher than in DEF. Tmin varied seasonally with lower values in the dry season. The hourly Tair had the same phase at both sites, but the magnitudes were different (Figures 3C and 3D). The amplitude of Tair in the DEF was on average 3.7ºC in the dry season and 2.5ºC in the wet season higher than into the FOR. The maximum hourly Tair in DEF was on average 3.0ºC in the dry season and 2.8ºC in the wet season higher than into the FOR, while the minimum Tair hourly in DEF was 0.3ºC higher in the wet season and 0.7ºC lower in the dry season than into the FOR.

Figure 5 – Cerrado-Amazonia Transition in Mato Grosso, Brazil



Source: Authors (2022)

In where: Correlogram of precipitation (Ppt; mm); solar radiation (Rg; W m^{-2}); average air temperature (Tair; °C); maximum air temperature (Tmax; °C); minimum air temperature (Tmin; °C); relative humidity (RU; %); soil temperature (Tsoil; °C); wind speed (Ws; m s^{-1}).

Variability in climate on the micro-scale is driven by topography and vegetation cover (HARDWICK; TOUMI; PFEIFER; TURNER; NILUS; EWERS, 2015). Canopy cover has a strong influence upon extreme climate conditions. First, plant canopies absorb, scatter, and reflect incoming solar radiation, thus reducing the amount of energy that penetrates through to the soil and below-canopy air (HARDWICK; TOUMI; PFEIFER; TURNER; NILUS; EWERS, 2015). Second, plant canopies absorb momentum from the air and thus wind speed decreases with depth within the canopy (BRUNET, 2020). Finally, the amount of water vapor that air can hold is strongly dependent upon the air temperature (HARDWICK; TOUMI; PFEIFER; TURNER; NILUS; EWERS, 2015). Additionally, transpiration within the forest keeps the air moist and cooler than deforested landscapes due to shade and the role of evaporation and transpiration in reducing sensible heat (ELLISON; MORRIS; LOCATELLI; SHEIL; COHEN; MURDIYARSO; GUTIERREZ; NOORDWIJK; CREED; POKORNY; GAVEAU; SPRACKLEN; TOBELLA; ILSTEDT; TEULING; GEBREHIWOT; SANDS; MUYS; VERBIST; SPRINGGAY; SULLIVAN, 2017).

Lower air temperature in the dry season is probably caused by cold fronts, in which there are sudden drops in solar incidence due to the presence of cloud cover (BIUDES; VOURLITIS; MACHADO; ARRUDA; NEVES; LOBO; NEALE; NOGUEIRA, 2015). Cold air transported by fronts from the South (“*friagens*”) can persist for several days, causing low temperatures in the dry season. On the other hand, the highest maximum air temperature in the dry season is due to little cloud formation, which allows for a greater incidence of direct solar radiation on the surface. Furthermore, the greater variation in air temperature in DEF is possibly related to the higher incidence of solar radiation and lower water availability (BIUDES; VOURLITIS; MACHADO; ARRUDA; NEVES; LOBO; NEALE; NOGUEIRA, 2015). Soils without vegetation cover are likely to receive a higher incidence of solar radiation and have higher evaporation since the canopy absorbs the incident radiation before reaching the soil surface, which causes a reduction in soil temperature (YUAN; ZHU; ZHENG; ZHAO; CHEN; RILEY; CAI; MA; LI; WU; CHEN, 2021).

The relative humidity (RH) in both sites had a positive correlation with ppt and negative correlation with Rg but did not correlate with Tair (Figures 4 and 5). The RH into FOR was 7% higher than in DEF (Table 2). There was a significant effect of season on RH in which RH during the wet season was 11% and 13% higher than the dry season into FOR and in DEF, respectively. The RH lowest values occurred in August, and the higher ones occurred in January (Figure 2D). As the hourly Tair, the hourly HR was in phase at both sites, but with different magnitudes (Figures 3E and 3F). The amplitude of RH in the DEF was on average 10.1% in the dry season and 14.4% in the wet season greater than into the FOR. The minimum hourly RH in DEF was on average 10.2% and 14.6% lower than into the FOR in the dry and wet season, respectively.

The relative air humidity followed the seasonal pattern of precipitation, but it varied inversely with the air temperature. Relative humidity is directly associated with energy and water availability (YUAN; ZHU; ZHENG; ZHAO; CHEN; RILEY; CAI; MA; LI; WU; CHEN, 2021). In forests, the relative humidity is higher due to the vegetation's ability to absorb a greater fraction of the precipitation and retain it before it runs off surface, as well as extracting water from deep areas of the soil for transpiration, causing greater water vapor in the air (BIUDES; VOURLITIS; MACHADO; ARRUDA; NEVES; LOBO; NEALE; NOGUEIRA, 2015). The change in vegetation cover alters surface moisture, as it increases evaporation, causing greater loss of available surface energy as sensible heat, rather than latent heat (YUAN; ZHU; ZHENG; ZHAO; CHEN; RILEY; CAI; MA; LI; WU; CHEN, 2021). This effect influences the warming of the air temperature close to the surface, as well as reducing the flow of relative air humidity, which can reduce the amount of moisture available for precipitation (YUAN; ZHU; ZHENG; ZHAO; CHEN; RILEY; CAI; MA; LI; WU; CHEN, 2021). In addition, a decrease in the air relative humidity during daytime is caused by an increase in air temperature due to an increase in solar radiation (BIUDES; VOURLITIS; MACHADO; ARRUDA; NEVES; LOBO; NEALE; NOGUEIRA, 2015). In this case, low air relative humidity in the afternoon (12:00 and 15:00) is due to an increase saturation pressure (ANDERSON, 1936).

The soil temperature (Tsoil) had a complex interaction with the micrometeorological variables in both sites. The Tsoil in DEF had a strong positive correlation with Rg but did not correlate with Rg into FOR (Figures 4 and 5). The Tsoil was positively correlated with Tair in both sites, but the Tsoil into FOR had a positive correlation with ppt and RH, while the Tsoil in DEF had a negative correlation with ppt and RH. The Tsoil in DEF was 18% higher than FOR. The Ts in FOR was not significantly affected by season, but Tsoil in DEF in the dry season 2013 was 8% than the wet season (Table 2). The maximum Tsoil occurred in October 2012 and September 2013 in both study sites, but the minimum Tsoil occurred in June 2012 and February 2013 in DEF and occurred in August in FOR (Figure 2E). The hourly Tsoil on both sites were different in phase and magnitude (Figures 3G and 3H). Tsoil into the FOR was delayed by an average of 1.5h and 0.5h in the dry and wet season, respectively. The amplitude of Tsoil in DEF was, on average, 7.6ºC in the dry season and 4.4ºC in the wet season, higher than into the FOR. The maximum Tsoil in the DEF was on average 10.5ºC in the dry season and 6.1ºC in the dry season higher than into the FOR and the minimum Tsoil in the DEF was on average 2.9ºC in the dry season and 1.7ºC in the wet season greater than into the FOR.

Soil temperature has an important role in agricultural, hydrological, meteorological, and climatological studies. Soil temperature plays a key role in physical (soil evaporation and infiltration), biological (plant growth and seed germination), and chemical (litter decomposition and nutrient mineralization) processes, affecting terrestrial ecosystem processes and functions (QI; ZHANG; COSH, 2019). Besides, soil temperature fluctuations play a substantial role on the soil moisture status and controls energy exchange of soil-atmosphere interactions (YUAN; ZHU; ZHENG; ZHAO; CHEN; RILEY; CAI; MA; LI; WU; CHEN, 2021). Soil temperature data are critical for simulating hydrological and related processes on the land surface and it is affected by many factors, such as meteorological conditions, soil topography, water content and plant canopy cover (QI; ZHANG; COSH, 2019).

The vegetation presence allows the canopy partially intercepts or reflects the solar radiation, hence reducing the radiation absorption of soil and resulting in lower soil and air temperature nearby (YUAN; ZHU; ZHENG; ZHAO; CHEN; RILEY; CAI; MA; LI; WU; CHEN, 2021). Then, as soon as the solar energy has reached the soil surface, it is either stored or transmitted down the soil profile or propagated as sensible heat back to the atmosphere in dry soil conditions (MENGISTU; VAN RENSBURG; MAVIMBELA, 2017). On the other hand, a considerable amount of the energy is expended as latent heat of vaporization in wet soil conditions (MENGISTU; VAN RENSBURG; MAVIMBELA, 2017). In addition to plant canopy, litter cover is an important mediators of soil temperature and moisture because it intercepts incoming/outcoming net radiation and it is also indirect regulator of other energy fluxes (NI; CHENG; WANG; GARG, 2019). Soil heat flux controls changes in soil profile temperature, then changes in soil temperature would be magnified significantly by reducing the vegetation cover and litter layer (YAN; YAN; CHEN; XIN; ELDRIDGE; SHAO; WANG; LV; JIN; CHEN; GUO; CHEN; XU, 2018). Therefore, soil temperature in vegetated soils is lower than in bare soils and fluctuation magnitude of soil temperature in vegetated soils is much smaller (NI; CHENG; WANG; GARG, 2019). In addition to cover conditions, soil temperature shows great variation in space and time due to heterogeneous soil thermal properties (QI; ZHANG; COSH, 2019). Thermal soil properties (heat capacity, thermal diffusivity, and thermal conductivity) are physical properties that control dictate the storage and movement of heat in soils and as such influence the temperature and heat flux in soils as function of time and depth. In general, sandy soils like the study area has lower specific heat and volumetric heat capacity than clay soils for the same water content and soil density, as well as sandy soil has higher thermal conductivity and diffusivity than clay soil (ABU-HAMDEH, 2003).

The wind speed (Ws) in both sites was positively correlated with Rg and negatively with ppt, Tair, and RH, except with Tsoil (Figures 4 and 5). The Ws was positively correlated with Tsoil in DEF and negatively correlated with Tsoil into FOR. The Ws in the

DEF was around 22-fold higher than into FOR (Table 2). The Ws varied seasonally with higher values in the dry season in both sites. The Ws in DEF was maximum in August and minimum in April 2012 and February 2013 (Figure 2F). The Ws into FOR was near to zero during the most study period, except from June to September 2012 and August 2013. Hourly Ws at both sites were in phase, but the maximum in DEF was on average 1.5 m s^{-1} in the dry season and 1.0 m s^{-1} in the wet season and the minimum Ws in DEF was on average 0.2 m s^{-1} in the dry season and 0.1 m s^{-1} in the wet season greater than within the FOR (Figures 3I and 3J).

Wind is generated by pressure gradients and modified by friction and the Coriolis force due to Earth's rotation (PERSSON, 1998). Seasonal mean wind speeds are influenced by macro-scale atmospheric circulations through the relationship between the locations of the Intertropical Convergence Zone (ITCZ) and South Atlantic Anticyclone (SAA). When the ITCZ moves northward of the Equator during spring SAA becomes a prominent feature that increase sea-level pressure (SLP) over Brazil causing faster wind speed during dry period in the study area. In addition, changes in terrestrial wind speed are also induced by anthropogenic activities due to changes in the surface roughness (WU; ZHA; ZHAO; YANG, 2018). Wind speed is the meteorological variable that presents the most significant change due to deforestation (WU; ZHA; ZHAO; YANG, 2018). As the surface roughness coefficient decreases, there would be an increase in windspeed (ZHOU; SUN; ZHU; ZHANG; TIAN; LIU; GUAN; YUAN, 2006). Inland, windspeed increases by approximately 80% after deforestation. The greater windspeeds diminished local humidity convergence and consequently reduced rainfall totals in nearby regions (WU; ZHA; ZHAO; YANG, 2018). On the other hand, forests also reduce wind speed through their aerodynamically rough, undulating canopy; with the decrease in wind velocity (ZHOU; SUN; ZHU; ZHANG; TIAN; LIU; GUAN; YUAN, 2006).

Overall, the diurnal cycles of temperature and wind are strongly influenced by processes in the atmospheric boundary layer, by turbulent diffusion and radiation, but also by the thermal coupling to the underlying surface through vegetation (WU; ZHA;

ZHAO; YANG, 2018). Diurnal wind speed is associated to higher surface temperatures during the day and the sensible heat peak in the afternoon resulting in increased instability in the planetary boundary layer which leads to more downward turbulent mixing of momentum. On the other hand, sensible heating from the surface can also generate spatial gradients in surface pressure fields and thus stronger winds during the day (DAI; DESER, 1999).

4 CONCLUSIONS

The micrometeorological variables of the Cerrado-Amazon Transition region studied had seasonal patterns. Precipitation had a hyper-seasonal pattern with 95% of the volume in the wet season (October to April), which influenced the seasonality of the other variables. Rg, Tair, Tsoil and Ws were higher in the dry season and RH was higher in the wet season of the studied region. Rg in DEF was 8-folds higher than in FOR, Tair in DEF was up to 11% higher than in FOR, RH in FOR was up to 14% higher than in FOR, Tsoil in DEF was 18% higher than in FOR and the Ws in DEF was 22-folds higher than in FOR. These results show that deforestation in the Cerrado-Amazon Transition region studied significantly influenced the seasonality and magnitude of the analyzed micrometeorological variables. As it is a region where the microclimate is poorly studied, more studies with more micrometeorological data collection points are necessary to represent a larger region with different physiognomies.

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