

Interannual Variability of Energy Flux in Atmospheric Instability Conditions at Pantanal of Mato Grosso-Brazil

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ABSTRACT

The energy balance partitions in wetlands have gained notoriety due to the dynamics and importance of these areas for regional and local climate. Thus, the study was conducted about seasonal and interannual behavior energy fluxes, as well as the influences of the conditions of atmospheric stability and instability. The results showed highest fluxes happened in instability atmospheric conditions. The fluxes of latent and sensible heat showed seasonal variation, indicating that the water availability in the atmosphere has influence on the site energy partition, but the interannual patterns remained similar during the two years of study.

Keywords: Latent Heat; Sensible Heat; Energy Partition; Wetlands

1. Introduction

The flood pulse is considered the driving force of the Pantanal and the intensification of the season of dry and wet seasons are the result of multi-annual fluctuations in water level that influence the limnological seasonal characteristics, ecological and biological [1]. October months are the rains begin and it finish between February and May, July and August are characterized as dry months in this region, often causing hidric stress to the plants [2].

Vochysiadivergens is considered an invasive species in Pantanal having a good adapting in flood area. This species incursion in the Pantanal happened in the early 70 s, after the end of an intense and multi-annual period of dry [3]. In not flooded areas the presence of Vochysiadivergens is rare or absent, but present a better development in newly sedimented areas along rivers [4]. In wetlands, there is no problem with this species, but when it reaches the highest parts of Pantanal and advancing toward fields forming forests, it becomes a problem, because it occupies Pasture areas [5].

The apparent cause of the spread of the species in the region may be related to the alternation of major floods and droughts that occur in the Pantanal and also by deforestation caused by livestock farmers in the region, increasing the area available for the plant to establish. These factors can cause shrinkage of native vegetation and increases in populations of this species, giving the vegetation an irregular character in time and space than may lead to short and medium term changes in Pantanal

region climate [3].

The flux of latent and sensible heat can be obtained by micrometeorological methods, direct and indirect (estimated), the last one having the advantage of not altering the environment. For direct measurement methods has the eddy covariance system, which takes into consideration the fluctuation of the concentration of water vapor, temperature and fluctuation of wind speed to calculate the flux and latent heat sensitive respectively [6,7]. The advantage of using direct measures is that small fluctuations in very low intervals of time are obtained, the disadvantage is the value for the acquisition of the equipment.

The LE and H quantification by Bowen ratio method have been widely used in the last decade, for determining the energy balance in many studies about the energy dynamics of forest and the management availability of water for certain crops by evapo transpiration estimated by the latent heat flux [8-12].

The atmospheric stability can be defined as a condition in which atmospheric air upward movements are absent or permanently inhibited, whereas the condition of instability is defined as the atmospheric state in which prevail the vertical movements. The characterization of these atmospheric conditions is realized according to the temperature distribution of air, *i.e.*, an air layer is considered stable or unstable depending on the value of vertical temperature gradient observed in the layer. It should also consider the situation in which the vertical temperature

gradient in the atmospheric layer coincides with the rate dry adiabatic. In such condition, the air parcel to ascend or descend will always have the same temperature of the medium that it surrounds, without resistance nor furthering of the vertical movement of the air layer, featuring neutral atmospheric condition [13].

The objective of this work was to study the seasonal behavior of the energy fluxes for stability and instability atmospheric conditions in an area of Vochysiadivergens at Pantanal of Mato Grosso-Brazil.

2. Materials and Methods

2.1. Study Area

The study was conducted in an area located in the Private Reserve of Natural Heritage—PRNH SESC—Pantanal, in Barão de Melgaço city—MT, distant 160 km from Cuiabá—MT where a micrometeorological tower was installed at 32 m in height (16°39'50"S, 56°47'50"W) and 120 m level. This area has a mono-dominant vegetation of Cambará (Vochysiadivergens, Phol), known locally as cambarazal, with canopy heights ranging from 28 to 30 m (Figure 1).

2.2. Measurements

The net radiation was measured for one net radiometer (Kipp&Zonen Delft, Inc., Holland), and the heat flux in soil was measured by two fluximeters (HFT-3.1, REBS, Inc., Seattle, Washington) installed at 0.05 m e 0.25 m depth. The gradients of temperature and humidity were estimated by two thermohygrometers (HMP 45 C, Vaisala, Inc., Helsinki, Finland) installed at 33.7 m e 37.7 m height in micrometeorological tower.

2.3. Methods

Atmospheric stability (ξ) was calculated using two methods (Equations (1) and (2)).

$$\xi = -\frac{0,4gzH}{\rho c_p T_k u^{*3}} \quad (1)$$

where, g is the gravitational acceleration (9.8 ms^{-2}), T_k is the air temperature (K), u^* is the velocity of air friction (ms^{-1}), ρ is the air density ($1.292 \text{ kg}\cdot\text{m}^{-3}$), c_p is the specific heat of the humid air ($1013 \text{ Jkg}^{-1}\cdot\text{C}^{-1}$), H is the sensible heat flux where z is the height was measured wind speed.

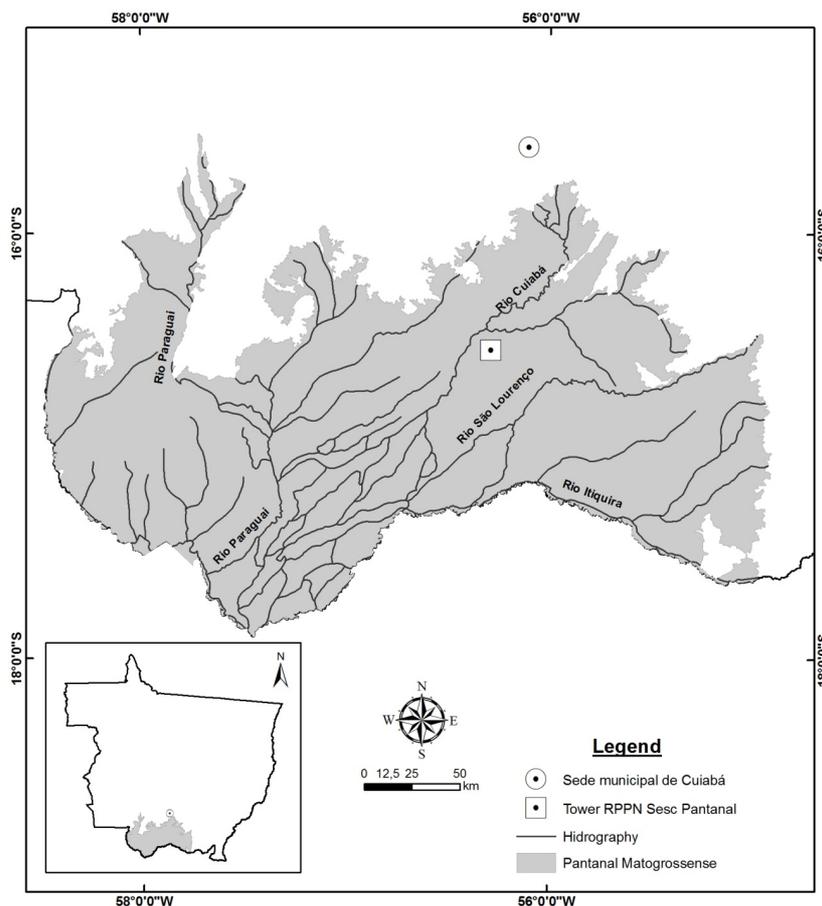


Figure 1. Localization of the micrometeorological tower in the RPPN-SESC Pantanal in Mato Grosso-Brazil.

The sensible (H) and latent (LE) heat fluxes were calculated according to Equations (2) and (3), respectively.

$$H = (R_n - G) \left(\frac{\beta}{\beta + 1} \right) v \tag{2}$$

$$LE = \left(\frac{R_n - G}{\beta + 1} \right) \tag{3}$$

Where R_n is net radiation, G is the soil heat flux and β is the Bowen ratio, given by:

$$\beta = \gamma \frac{\Delta T}{\Delta e} \tag{4}$$

where Δt is difference temperature between two levels ($^{\circ}\text{C}$), the difference Δe pressure of water vapor between two levels (kPa) and the constant γ psychometric (0.0626 kPaC^{-1}).

3. Results and Discussion

3.1. Seasonality of Weather Condition and Patterns of Latent and Sensible Heat Flux

Table 1 shows the daily average values of atmospheric conditions (stability and instability) and the latent heat and sensible in the study area.

According to **Table 1**, it was noted that the highest values of the latent heat and sensible occur with atmospheric in stability, which is because in unstable conditions conducive to turbulence that is the most favorable condition for energy transferring and matter between surface and atmosphere.

The daily average values of seasonal latent heat in the rainy season were higher than in the dry, which also resulted in an increase in the sensible heat flux during the dry period, indicating that the water content due to the precipitation region is a factor determining the amount of energy from the sun which is used to evaporate the water and increased temperature.

This conversion of solar energy into latent and sensible heat is critical for the regulation of ecosystems. According to [14], temperature and humidity conditions within and above a forest are the result of transmission and absorption of solar energy on the surface of the canopy, its conversion into sensible and latent heat and the allocation of light and heat in a forest.

The average daily values of atmospheric conditions showed that both stability and instability remained approximately the same values in both periods (rainy and dry) during the two years studied (2007 and 2008), which indicates a weather regulation in the region of the study.

Table 1. showsthe daily average values of atmospheric conditions (stabilityand instability) and the latent heat and sensible in the study area.

			2007	2008
Wetseason	Instability	maximum	-0.11	-0.22
		minimum	-0.61	-0.60
		mean	-0.40	-0.39
	Stability	maximum	0.16	0.09
		minimum	-0.01	-0.01
		mean	0.05	0.03
	LE—Unstable	maximum	547.04	454.49
		minimum	51.02	-41.08
		mean	306.42	280.57
	LE—Stable	maximum	94.74	109.05
		minimum	-34.82	-21.6
		mean	0.3	15.94
H—Unstable	maximum	111.54	107.94	
	minimum	9.72	-6.82	
	mean	59.73	61.48	
H—Stable	maximum	18.54	22.31	
	minimum	-7.47	-3.36	
	mean	0.76	3.96	
Dryseason	Instability	maximum	-0.18	0.15
		minimum	-0.57	-0.62
		mean	-0.37	-0.36
	Stability	maximum	0.09	0.11
		minimum	-0.02	-0.01
		mean	0.01	0.02
	LE—Unstable	maximum	348.47	352.96
		minimum	-7.4	-46.01
		mean	234.02	216.03
	LE—Stable	maximum	60.42	77.23
		minimum	-39.93	-37.91
		mean	0.57	4.9
H—Unstable	maximum	118.83	149.26	
	minimum	-1.41	-7.76	
	mean	58.57	66.02	
H—Stable	maximum	15.68	23.06	
	minimum	-15	-14.91	
	mean	0.33	0.7	

3.2. Inter-Annual Variability of Weather Conditions and Patterns of Latent and Sensible Heat in the Rainy Season

The values in **Table 1** and **Figure 2** indicate that the energy converted into latent heat flux was on average higher than the energy converted into heat sensitive within two years of study during the rainy season, except on condition of stability of the year 2007, which indicates that the amount of water present in the atmosphere is a

regulating agent of the ecosystem in question, this result was found by [2].

Another important factor is that in analyzing inter-annual patterns in atmospheric conditions (stability and instability) were between one year and one which also occurred with the latent heat and sensible, who have followed these conditions, with higher instability values than the stability in the two years of study, thus indicating that during the wet season of 2007 and 2008 standards in these variables kept the same.

3.3. Inter-Annual Variability of Weather Conditions and Patterns of Latent and Sensible Heat in the Dry Season

According to **Figure 3**, it was noted that as in the rainy period between the study period, in the dry most of the

available energy to the ecosystem was converted into latent heat, showing that even in periods with little or no precipitation the evaporative requirement is relatively high compared with the sensible heat flux, demonstrating that the latent heat flux is the main component of the energy balance in this region.

The same to the rainy season, the highest values of latent heat flux and sensible culminated with the conditions of atmospheric instability, which as already mentioned in Section 3.1, this condition favors the turbulence that promotes the energy transfer between the surface and atmosphere through the fluxes of latent and sensible.

Another important factor is the greater variability of the data sensible and latent heat flux in the dry season than in rainy season in both years studied, this is caused

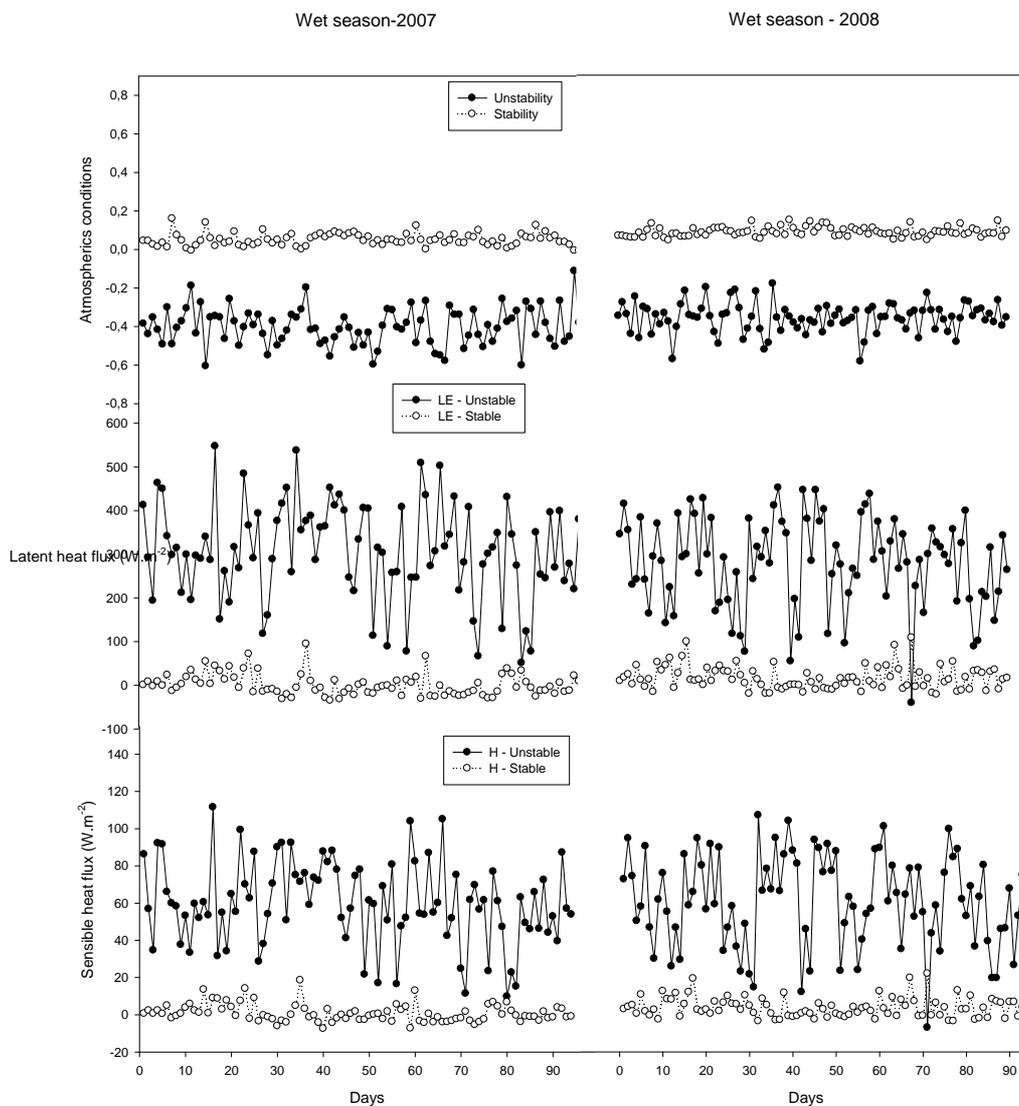


Figure 2. Daily average values of conditions atmospheric stability, atmospheric instability and flux of latent and sensible heat during the wet season in the years 2007 and 2008.

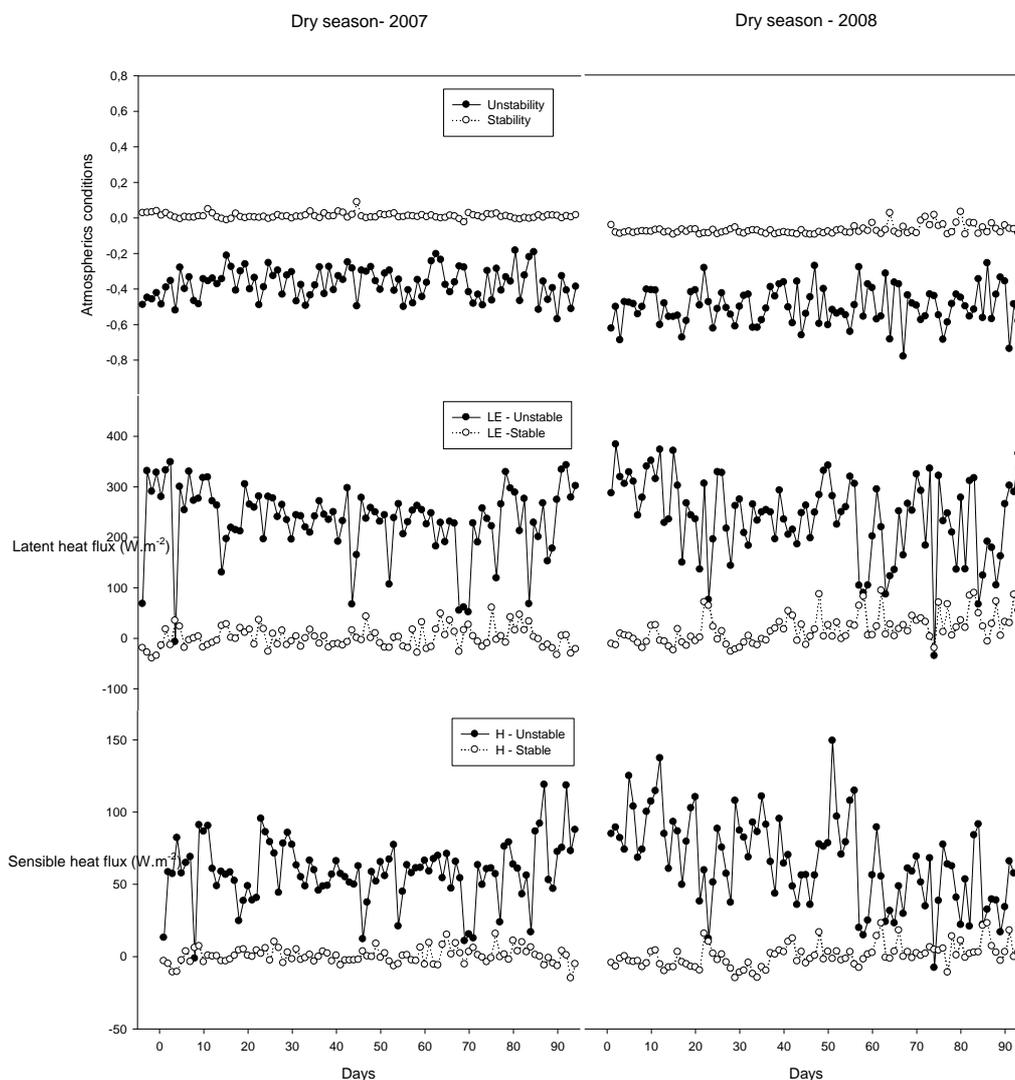


Figure 3. Daily average values of conditions atmospheric stability, atmospheric instability and flux of latent and sensible heat during the dry season in the years 2007 and 2008.

by the fact that there is greater variation in temperature in the region due to low water content in the atmosphere and also for this period include the winter season than in the southern hemisphere occurs between June and September, which causes abrupt changes in temperature, thus causing a greater variability in the energy flux data. This greater variability in temperature data during the dry period is described in [15].

Lower values of LE during the dry period can be explained by lower temperatures, drier air and lower radiation (winter solstice), and is a limiting feature of this water at this station canopy. During the dry season, there is a decline in water content in soil and can limit evaporation and water availability for plant root surface [16]. However, higher values of evapotranspiration in the wet season were related to increased rainfall and flood water depth [17].

Lower values of LE, during the dry period, were also reported in the Cerrado and Amazon transition forest-savanna in the Midwest, while in tropical rain forests located in Manaus, Santarem and Rondonia city were reported lower values of evapotranspiration during the wet season [18,19].

Thus, the partition of energy in the Pantanal regions is strongly influenced by water availability in soil and atmosphere and the conditions of instability and stability atmospheric.

4. Conclusions

Latent and sensible heat flux was influenced by weather conditions in the region, and the condition of instability caused the highest values of energy flow by favoring the transport of energy between the surface and atmosphere through turbulence.

The most of available energy were converted into latent heat in the two years of study, showing that the water content is a regulatory agency in the region.

The variables studied (instability, stability, latent heat and sensible heat) showed similar patterns for the same period, the interannual analysis.

Water availability and season influenced the partitioning of energy of site.

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