RADIATIVE FLUX DIVERGENCE OVER BRAZILIAN PANTANAL DURING MAY 1998

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RESUMO

Estimativas acuradas do saldo de radiação sobre superfícies naturais são essenciais para a determinação da energia disponível para os processos de transferência de calores sensível e latente entre a superfície e a atmosfera. Assim sendo, determinaram-se neste trabalho as taxas de aquecimento e resfriamento na camada limite superficial sobre região do Pantanal Sul Mato-grossense, durante o período de transição entre as estações úmida e seca. Os resultados mostraram altos valores de divergência e convergência, o que pode ser associado à presença de umidade e à divergência de fluxo de calor latente na região.

Key-words: Pantanal, warming, cooling, net radiation.

INTRODUCTION

Accurate estimates of net radiation above natural surfaces, including e. g. soil, grassland, crops, forests and wetlands, are important for the determination of the energy that is available for latent heat (water vapor) and sensible heat transfer processes between these surfaces and the atmosphere. Such estimation is therefore important for the determination both of the evaporation in hydrological studies and of the heat budget in climatological and agricultural meteorology studies.

The atmospheric planetary boundary layer height varies over a wide range (from several tens of meters to several kilometers) and depends principally on the following variables, among others: rate of heating or cooling of the surface, wind speed, roughness and other topographical characteristics of the surface, large -scale vertical motion, horizontal advection of heat and moisture (Arya, 1988).

In many theoretical studies of the nocturnal boundary layer (NBL) the radiative flux divergence has been neglected, but results from Garratt and Brost (1981) of NBL simulations, where cooling is included, gave an indication of the importance of the radiative term in the

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determination of the thermodynamic structure of the NBL. Ever since other studies were conducted to analyze the cooling rate at different heights (André and Marth, 1982; Stull, 1983a,b; Cerni and Parish, 1984; Carlson and Stull, 1986; Turton and Brown, 1987). It is clear that proper specification and evolution of the terrestrial and atmospheric fluxes requires a knowledge of the absorption and emission characteristics of the atmosphere. In particular, the absorption and emission are sensitive and vary with the vertical profiles of water vapor and temperature. True representation of radiative cooling is of central importance in understanding certain dynamic features of the nocturnal boundary layer, especially gravity-driven slope flows such as mountain-valley circulation or katabatic winds (Cerni and Parish, 1984).

The objective of this work is to investigate the radiative cooling rate at the surface layer above the Southern region of the Pantanal wetland of South Mato Grosso State during the flood season.

SITE DESCRIPTION AND DATA

The place of study is located in the southern region of Pantanal wetland of South Mato Grosso State, Brazil. The region is characterized by seasonal inundation pattern (Hamilton et al., 1996) and peculiar fetch conditions, with typical vegetation cover called "paratudal" *(Tabebuia caraiba)*. A field campaign was carried out, as part of a broad experimental program to study the characteristics of the weather and the climate of the central region of Brazil.

Measurements were made using a 21 m aluminum tower located near to the Base site of Pantanal Studies of the Federal University of South Mato Grosso - UFMS (19°33'48,.2"S, 57°00'53.8"W) , and near to the river Miranda.

The net radiation data (10 minutes averages) were acquired using net radiometers (Rebs), installed at 4 and 20.4 m on the tower, and recorded in a data logger (CR10 Campbell Scientific). For the present study, 15 days, from 13 to 27 May (Julian days 133 to 147, respectively) were chosen. During this period, the predominant wind direction was southerly, varying between south westerly and south easterly, but there was drastic change in the wind direction with the passage of large scale synoptic disturbances.

METHODOLOGY

The rate of warming or cooling of a layer of air due to change of net radiation with height can be calculated from the principle of conservation of energy. Considering a thin layer between the levels z and z + Δz, where the net radiative fluxes are $R_n(z)$ and $R_n(z + \Delta z)$ one gets

$$r\ Cp\ \Delta z\ (\partial T/\partial t)_R = R_n(z+\Delta z) - R_n\ (z) = (\partial R_n/\partial z)\ \Delta z$$

or $$(\partial T/\partial t)_R = (1/rCp)(\partial R_n/\partial z)$$

where ρ is the mass density, Cp is the specific heat at constant pressure, $(\partial T/\partial t)_R$ is the rate of change of temperature due to radiation and $\partial R_n/\partial z$ represents the convergence or divergence of net radiation (Arya, 1988). Radiative flux convergence occurs when R_n increases with height ($\partial R_n/\partial z > 0$) and divergence occurs when $(\partial R_n/\partial z) < 0$. The former leads to warming and the later to cooling of the air.

RESULTS AND DISCUSSIONS

During the period studied, the ground was covered with a thin layer of water having vegetation with floating root system, e.g., *Eichhrornia crassipes* ("aguapé"); the water level of the surface was 0.089 m on May 14 and decreased to 0.038 m on May 27. The water layer affects the radiation measurements, specially during sunset and sunrise periods, and latent heat flux.

The cloud cover, in hourly octaves, as shown in Table 1, comprises of clear and cloudy days during the period. Stratocumuli were the predominant clouds.

Table1 - Cloud cover near to the tower during measurements period.

Julian Day	**Day**	**Hour**											
		7	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
133	13	7	7	7	6	6	4	2	3	1	2	2	3
134	14	8	8	8	8	8	8	8	8	8	8	8	8
135	15	8	8	8	8	8	8	8	8	8	8	8	8
136	16	8	8	8	7	7	5	6	5	4	5	3	1
137	17	3	3	1	2	2	3	2	2	2	1	2	5
138	18	0	0	0	0	1	2	1	1	1	1	0	0
139	19	0	0	0	0	0	0	0	0	0	0	0	0
140	20	0	0	0	0	0	0	0	0	0	0	0	0
141	21	0	0	0	0	0	0	0	0	0	0	0	0
142	22	0	0	0	0	0	0	0	0	0	0	0	0
143	23	0	0	0	0	0	0	0	0	0	0	0	0
144	24	1	1	1	1	1	0	0	0	0	0	0	0
145	25	0	0	3	3	6	6	6	7	7	7	4	4
146	26	8	7	7	8	8	8	7	7	7	8	8	8
147	27	8	8	7	7	5	7	7	8	8	8	7	7

The inflection points of the diurnal variation of net radiation for both heights (4 and 20.4 m) are shown in Table 2: there are larger fluctuations in the inflection points near to the ground, i. e., at 4 m.

Table2 - The inflection points in diurnal variation of net radiation

Day	**Morning time of the 1st positive value**		**Evening time of the 1st negative value**	
	4 m	**20.4 m**	**4 m**	**20.4 m**
133	6:20	6:20	16:50	16:50
134	6:40	6:50	17:00	17:00
135	6:30	6:30	17:10	17:00
135	6:40	6:40	16:50	17:00
137	6:50	7:00	16:40	16:50
138	6:50	6:50	16:40	16:50
139	6:40	6:50	16:40	16:50
140	6:30	6:40	16:40	16:50
141	6:30	6:50	16:40	16:50
142	6:50	6:50	16:50	16:50
143	6:40	6:50	16:40	16:50
144	6:40	6:50	16:50	16:50
145	6:30	6:50	17:00	17:00
146	6:30	6:40	17:40	17:30
147	6:40	6:40	17:00	17:00

In the daytime, during clear skies, the net radiation is dominated by the net shortwave radiation.

The radiative flux convergence occurs mainly between 14 and 16 h local time in all days. The maximum warming (10 K/h) of the air is observed on day 140 (May 20), which is a clear day (Figure 1a). This large value can be explained due to warming of the superficial layer most probably due to the convergence of latent heat flux. The minimum warming (1 K/h) is observed on day 147 (May 27), a predominantly cloudy day (Figure 1b). At night, the net radiation is entirely due to net longwave radiation and the radiative flux divergence, which predominates most of the time during the period analyzed. The maximum cooling of the air, as high as -8 K/h, was observed on clear days (days 138, 140, and 143) . It should be mentioned here that the cooling rates of the order of 1 to 3 K/h in many field experiments were quoted by Stull (1988). The cooling rates observed in Pantanal are high values compared to those quoted by Stull. It can be explained due to the presence of moisture, which is abundant, and plays an important role in the radiative cooling. In other words this may be attributed to the latent heat flux convergence. Besides the latent heat, the vegetation also plays an equally important role by pumping moisture into the atmosphere by transpiration.

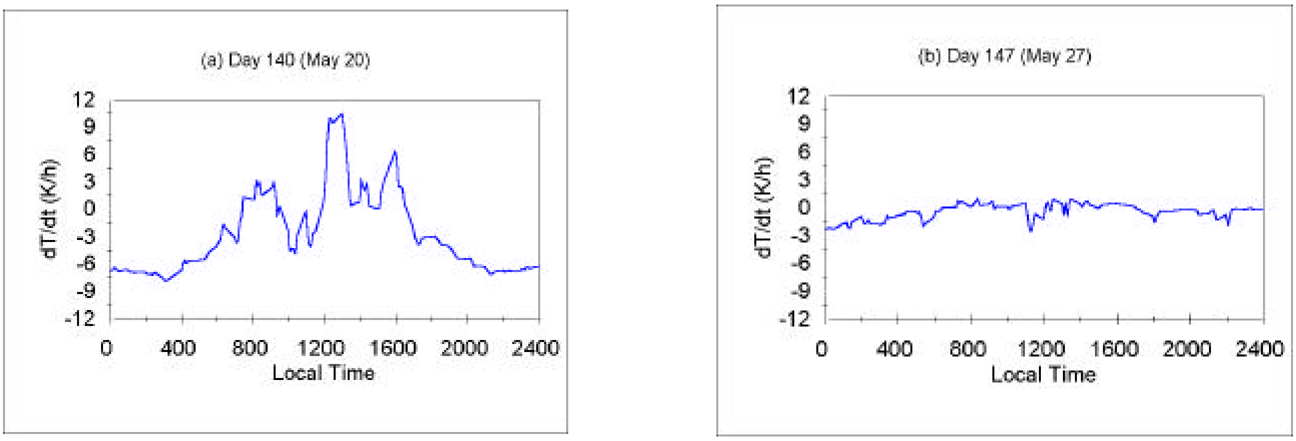

Figure 1 - Radiative flux convergence or divergence in the lower atmosphere at Pantanal.

CONCLUSIONS

The cooling and warming rates observed in Pantanal during the observation period (days 133 to 147) are high, especially on clear days. In this region, the moisture and the vegetation play an important role in the radiation balance and, thus, in the cooling and warming rates.

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