Analysis of multiscale temporal atmospheric oscillations in Caxiuanã – PA

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Resumo: Utilizaram-se dados referentes ao ano de 2008 coletados na torre micrometeorológica situada na Floresta Nacional de Caxiuanã (PA). Para a análise de múltiplas escalas, foi aplicada a Transformada em Ondeletas aos dados de temperatura do ar (T_{ar}), saldo de radiação (R_n) e vento horizontal na superfície (V_h). Os resultados mostram uma maior quantidade de energia de T_{ar} e de R_n associada a escala de tempo do ciclo diurno, principalmente, durante o período seco, de junho a novembro. Além disso, notam-se conexões entre as escalas intrasazonal, sinótica e meso. O sinal do V_h apresenta maior intensidade de energia no período seco, com flutuações de alta freqüência mais destacadas que nos demais escalogramas T_{ar} e de R_n. Em geral, estas flutuações podem estar caracterizando a atuação dos sistemas meteorológicos de grande escala na estação chuvosa e dos sistemas de mesoescala no período seco da região.
Palavras-chave: Amazônia, Multiescala atmosférica, Ondeletas.

Abstract: We used data collected during 2008 on the micrometeorological tower located on the National Forest of Caxiuanã (Pa). To the multiscale analysis, the Wavelet Transform was applied to the data of air temperature (T_{air}), net radiation (R_N) and superficial horizontal wind (W_h). The results have pointed out that the most energetic scale on the scalegram of energy for T_{air} and R_N, mainly during the dry period (from June to November) is the one associated with diurnal cycle. Connections between intraseasonal, synoptic and mesoscale have been observed. The Wh signal presents more energy on the dry period, with highlighted fluctuations on the high frequency domain that does not appear on T_{ar} and R_N scalegrams. In general, this fluctuations may be characterizing the presence of meteorological systems of large scale during the wet season and mesoscale systems during the region's dry period.
Key-words: Amazonia, Atmospheric multiscale, Wavelet**.**

1- INTRODUCTION

The atmosphere has many different mechanisms and systems that work on different time and space scales. So, as a way to organize these phenomena and classify them, groups, based on time and space scales, have been created, such as: microscale (less than 1 hour), synoptic scale (more than 1 day, less than 1 week), intraseasonal (one to three months) and many others. The interaction between these scales can influence from the high frequency phenomena to the low frequency ones.

Some studies already have been performed in Brazil. Vitorino and Dias (2004), Silva et al (2006) and Pontes et al (2006) studied multiple scales utilizing the Wavelet Transform and all found links among different atmospheric flow scales that influence the generation of precipitation.

The atmosphere presents many different time scales on its movement, almost all studies do research on only one single scale, although is possible to determinate a relationship between phenomenon of a specific scale that interfere on other scales. One example is the MJO (Madden – Julian Oscilation). Was detected that during its passage on South America the SACZ (South Atlantic Convergence Zone) has its intensity altered by the MJO (CARVALHO et al., 2003).

On this work, the Wavelet Transform was used to identify and characterize multi-scale atmospheric signal for air temperature, net radiation and superficial horizontal wind collected on the micrometeorological tower of Caxiuanã (Pa). Also, we looked to identify the main time scales, giving them the right meteorological systems and mechanisms that define the local climate.

2.1- DATA AND METHODOLOGY

The data have been collected during the year of 2008 on the National Forest of Caxiuanã (PA, Brazil) by the instruments installed on the top of a micrometeorological tower that have 57m high. Air temperature, net radiation and wind (decomposed on “u” and “v) data have been sampled at each 30 minutes interval, to generate the time series used in this work. A non-stationary time series analysis tool, the Wavelet Transform (DAUBACHIES, 1992), has been applied to the available data set. The mother function used was the Morlet’s Transform (WENG AND LAU, 1994):

$$g\,(t) = e^{i\omega_0 t}\; e^{-t^2/2}$$

This transform give useful information regarding scale oscillations energy and phase (WENG AND LAU, 1994).

3- RESULTS

The figures below represent the results obtained from the analysis of the atmospheric signal with the wavelet transform. The top graphic is the time series and second the scalegram of energy (left) and global energy (right) on each scale, ranging from 2 hours to 2048 hours (about 80 days, intraseasonal), along all the year of 2008.

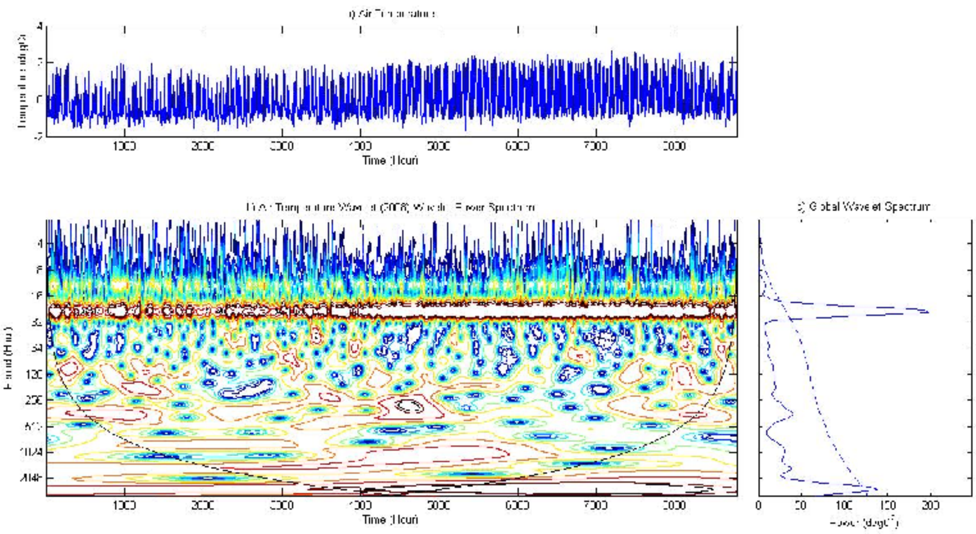

Figure 1: a) Air Temperature time series; b) Air Temperature energy scalogram; c) Air Temperature global power spectrum.

Analyzing the temperature graphics (Figure 1), is noticeable that the diurnal cycle is the most energetic scale (as we can see on “b” and “c”), being more energetic during the dry season (starting about July, at 4500 hour), when the large scale meteorological systems are not present at the region. The second most energetic scale is the 15-days (360 hours) scale, with more energetic picks occurring during the wet season (Jan-May), probably associated with Intertropical Convergence Zone (ITCZ), SACZ and upper level cyclonic vortex influences. These elements appear to be connected with higher frequency events, between 5 (120 hours) to 10 days (240 hours) oscillations caused by frontal systems or SACZ. Another connection appears linking to a lower frequency that oscillates between the 30-50 days (720-1200 hours), with a pick of energy in the middle of the year. This temperature oscillation was probably caused by MJO, whose interferences are also observed on others scales. Many energy picks have been detected between the 2 (48 hours) and 5 days (120 hours) scales, what could be linked with easterly waves action.

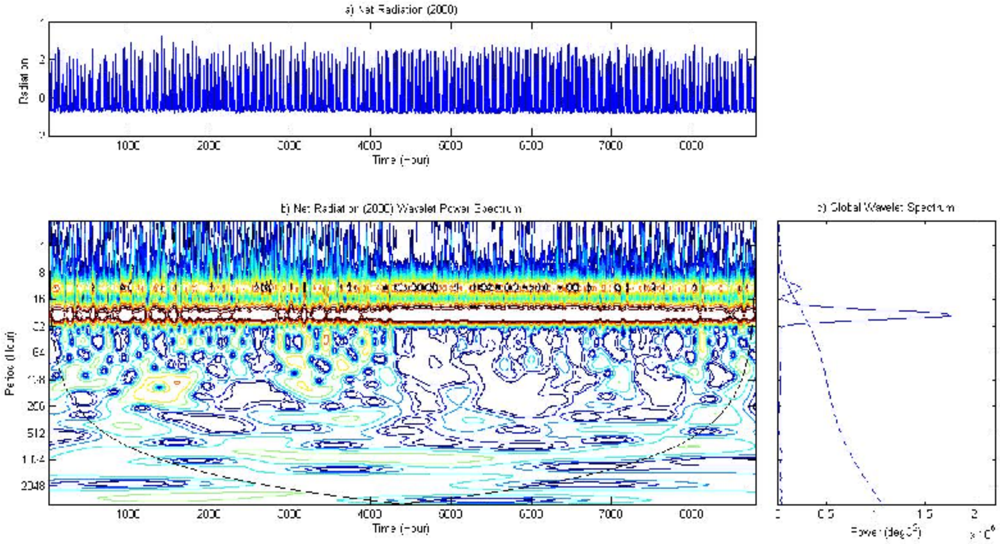

Figure 2: a) RN time series; b) RN energy scalegram; c) RN global power spectrum.

As was seen on the air temperature wavelet analysis, the net radiation (Figure 2) presents the higher energy level on the diurnal cycle, also with more energy during the dry season. The difference begins when the other scales were analyzed. After the diurnal scale, the energy is almost zero. To R_N, the other important time-scale is the semi-diurnal, probably due to atmospheric tides effects (LINDZEN, 1979).

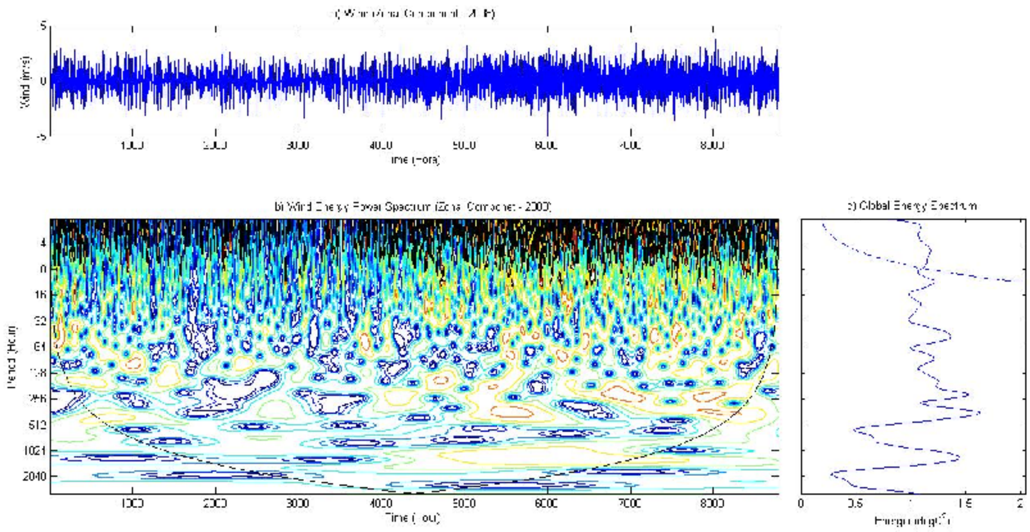

Figure 3: a) Zonal Wind time series; b) Zonal Wind power spectrum; c) Zonal Wind global power spectrum.

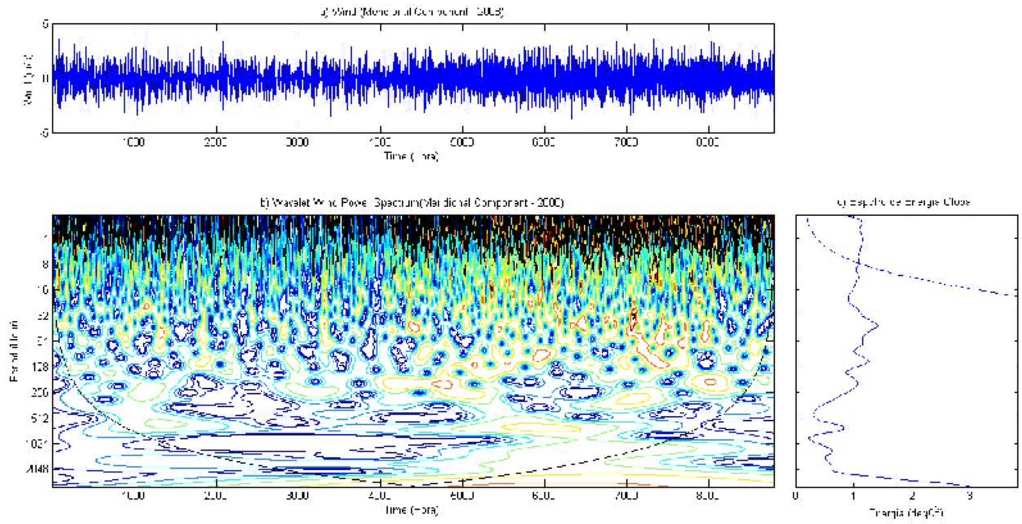

Figure 4: a) Meridional Wind time series; b) Meridional Wind power spectrum; c) Meridional Wind global power spectrum.

The wavelet analysis for the wind (Figure 3 and 4) signal has revealed some interesting results. The diurnal cycle disappears and more energy picks on the high frequency scale are shown on the power spectrum graphic, possibly representing the breeze systems. The dry season is more energetic than the wet season, this happen due to a higher wind speed during this time of the year. Many picks appears near the 5 day (120 hours) scale (mostly on the zonal wind) caused by easterly waves passage over the region. Once again, a high energy level was detected over the 40 days scale, reaffirming the idea of an MJO during the winter. Also, there is plenty picks of energy on 16 hours and 7 days, that can be also resulting of easterly waves or by the influence of squall lines.

4- CONCLUSIONS

The wavelet analysis applied to meteorological time series measured at Eastern Amazon Caxiuanã Reserve, has revealed that the diurnal cycle is the most energetic scale for air temperature, T_{air} and net radiation, $R_{N,}$ data, with higher energy occurring during the dry season, when the large scale meteorological systems that appear on the wet season, such as the ITCZ (15 days scales) and SACZ (5 to 10 days scale), are not present. These scales appear to be connected with an intraseasonal scale, corresponding to Madden Julian Oscillation (MJO) which probably has modulated the region’s weather. The RN analysis has revealed a possible influence of atmospheric tides over Caxiuanã, too. The wind scalegrams have shown more energy during the winter, when the wind speed is higher.

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