Atmospheric conditions in the Amazon River region the dry season (July 2016)

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Abstract- This paper is a brief report of the period in the dry season of the Amazon River from Iquitos (Peru) and Manaus (Brazil), from the 13th to the 30th of July, 2016, focusing on the Amazonian biosphere and atmosphere. The expedition collected georeferenced data for water samples, measurements of temperature, humidity, atmospheric pressure, surface temperature of the river, and wind direction. Preliminary results show that the temperature at the surface of the river and the environment in general points to possible climate normality.

Keywords*: *Amazon River; atmosphere; Amazonia;

I. INTRODUCTION

The Amazon Forest has rich biodiversity resources, such as fresh water and oxygen,and plays an important role in the global carbon cycle by the fact that along with the oceans it has large carbon (C) stocks captured from the atmosphere. The absorption of C by the trees is equal to approximately 17% greenhouse gas emissions [1]. However, the role of the forests in maintaining the climate of South America cannot be forgotten due to the hydrological cycle of interaction and humidity regulation within the tropical forest basin. After the rains the intense evaporation production and humidity recycling returns to the forest as rain again, and between 30% and 50% of the rainfall in Amazon is due to the evaporation recycling, [2].

To understand the interactions between the forest and the atmosphere, it is necessary to understand the turbulent changes in the Atmospheric Boundary Layer evolves continuously in response to the surface heating or to the cooling, assuming different states that can be described accurately by phase transitions (from day to night / or vice versa) [3]. According to [4], there are three main ways of exchanges between the surface and the atmosphere: radiation, momentum transference and latent heat transference and sensitive heat.

In recent research on the turbulent flows in Central Amazonia, [5] points out that the quantification of turbulent changes and their analysis should be well detailed in tropical forests, so it is necessary to perform micrometeorological measures with great representativeness of the regional climate. This allows obtaining good information about these turbulent flows. In [1] and [2], studies were done on the macro circulations and mesoscale operating in the Amazon and the dynamic processes that organize and promote the rainfall in the area. According to [1] and [2], the mechanisms that trigger rain in the Amazon can be grouped into three types:

- Resulting daytime convection from surface heating and favorable large-scale conditions;
- Instability lines originating on the north-northeast of the Atlantic coast;
- Convective clusters of medium and large scales, associated with the penetration of frontal systems in the S / SE region of Brazil and interacting with the Amazon region.

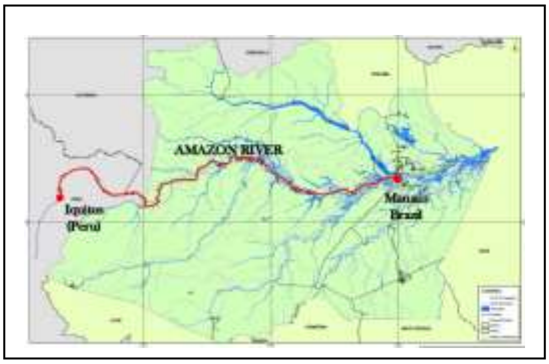


Figure 1. Conceptual Map of the Expedition - Amazon River (Peru-Brazil), 1st. Part 26 to 30 July 2016.

II. MATERIAL AND METHODS

This work was conducted during the first part of the Peru-Brazil River Expedition (Figure 1). Micrometeorology measurements were done using an order of magnitude flow analysis (Method of Covariances) as done according to [6], pages 105 and 106, as well as the graphics of rhythmic analysis of the types of the climate and systems, responsible for atmospheric dynamics of the period according to satellite images with information from [7]. Analysis of the Wavelet Transform from Morlet, following the methodology of [8], as the spectrum energy associated with the flow measures.

Figure 2: Lagragian Footprint Model [18], Weather Station - DAVIS - Vantage - Vue, the boat M / Monteiro II, 3***00 m ≤ R ≤ 500 m***, between unstable and stable conditions in July 2016.

Wavelet Transform

The term "wavelet" refers to a set of functions in the shape of small waves generated by expansions, $\psi(t) \rightarrow \psi(2t)$, and propagation, $\psi(t) \rightarrow \psi(t+1)$, of a generating simple function, $\psi(t)$, i.e., mother wavelet. It should be quadratically integrable within a real time or space $\left[L^2(\Re)\right]$, that is, it should have finite energy. The fact that its average energy is zero constitutes the admissibility condition of the function. Mathematically, the wavelet function in scale *a* and position *b* is expressed by:

$$\Psi_{a,b}(t) = a^{-1/2}\Psi\left(\frac{t-b}{a}\right) \qquad (1)$$

in which a and b are real and a>0. It should be noted that the equations (1) and (2), include the normalization term $a^{-1/2}$. Wavelet Transform (WT) is defined by:

$$\left(W_\psi f\right)(a,b) = \frac{1}{|a|^{1/2}}\int f(t)\psi\left(\frac{t-b}{a}\right)dt \ , \quad (2)$$

in which the temporal function f(t) is the series of data to be analysed. The equations (1) and (2), are similar and the only difference is the nucleus (kernel) of the equations, i.e., the nucleus in the FT is given by an exponential function and in the WT by a wavelet function.

There is the possibility of using different types of wavelet functions for WT depending only on the need. This way, these different types of wavelet functions can be classified into two large groups, namely: continuous wavelets and discrete wavelets. Among the best-known discrete wavelets are [9], [10] and [11]. The best-known continuous wavelet is Morlet, which also allows the analysis of the phase and the signal module when it is complex [12]. The Mexican hat wavelet [13], [14] and [15] is also mentioned in the literature; however, it is generally operated without a complex part. In the present study, we will use Morlet wavelet function and, therefore, it deserves greater attention.

The Morlet function is a complex wavelet that provides a wealth of information about the signal, such as the module and the phase [12] and [17]. This function has the following equation:

$$\psi(t) = e^{iK_\psi t}e^{-(|t|^2/2)} \qquad (3)$$

With the choice of Morlet WT and the measurements of 120-hours temporal series for obtaining the power wavelet spectrum, temperature, and global wavelet spectrum, we obtained results within 95% confidence. The support used was [10], WT modified routines.

Figure 3: Weather Station - DAVIS - Vantage - Vue, on the Amazon River in July 2016.

III. RESULTS AND DISCUSSION

In Amazon Climate [1] it is said that the availability of the solar energy through the energy balance is 30.7 $MJ.m^{-2}$.per day^{-1} in June / July. These values reduced by the atmospheric transmission being on average of the order of 15 $MJ.m^{-2}$.per day^{-1}.

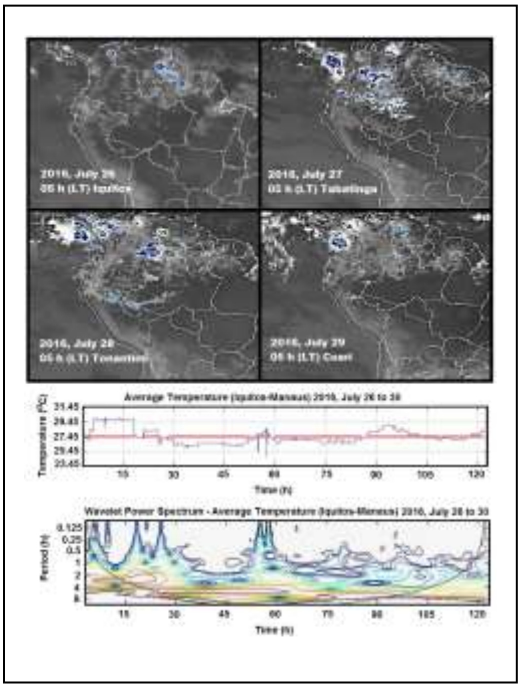
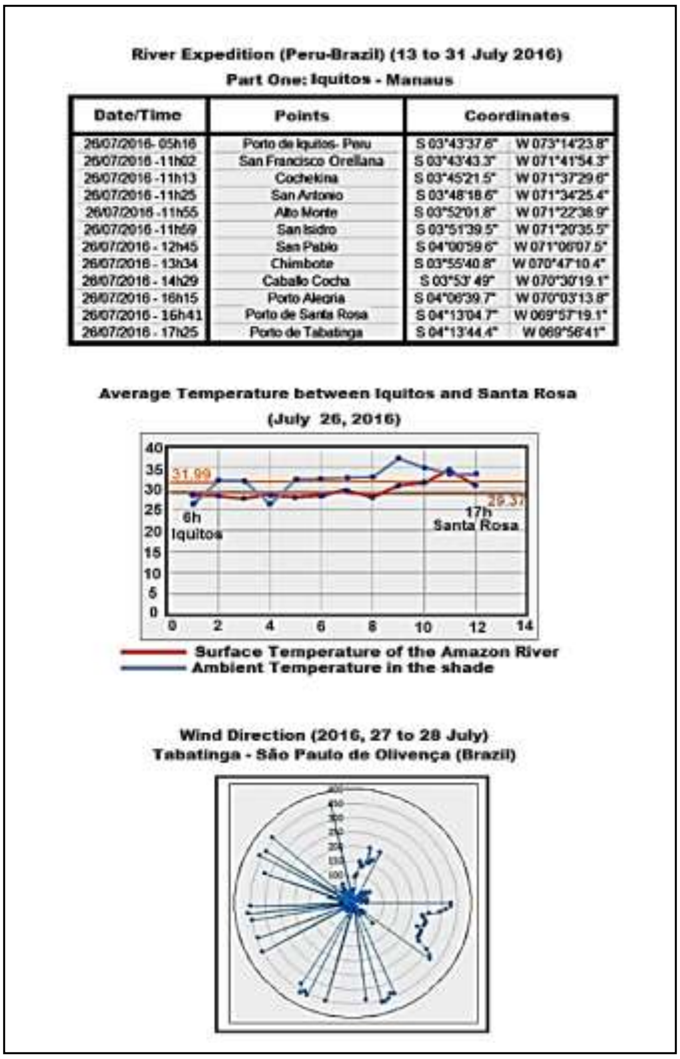


Figure 4: Satellite images between days 26-30 July 2016, identifying the atmospheric dynamics in the north of South America at 05 h 30 min (LT), time series below the average temperature of the Amazon River to the observed period and Morlet wavelet transform for characterizing the length (h) of occurrence of the most significant event, its duration (h) and their potential intensity warmer colors (red) at a reliability of 95% [9]

Figure 4 shows the satellite images panel [23], and the atmospheric dynamics between July, 26th to 30th, 2016 between Iquitos (Peru) and Manaus (Brazil) (yellow trace / Amazon river), at 05 h 30 min (LT - Local Time, UTC -5 and -4 UTC). There is a strong influence of the Intertropical Convergence Zone (ITCZ) over northern South America, with rainfall during the period, down from the satellite images it is possible to see the time series of the temperature from the period of 120 uninterrupted hours between Iquitos (Peru) and Manaus (Brazil). The average temperature was 27.45 ° C on the surface of the river, as data from obtained flows through a weather station (Davis - Vantage Vue K6250) coupled on the top deck of the boat M / Monteiro II (Figure 2).



River Expedition (Peru-Brazil) (13 to 31 July 2016)

Part One: Iquitos - Manaus

Date/Time	Points	Coordinates	
26/07/2016- 05h16	Porto de Iquitos- Peru	S 03°43'37.6"	W 073°14'23.8"
26/07/2016 -11h02	San Francisco Orellana	S 03°43'43.3"	W 071°41'54.3"
26/07/2016 -11h13	Cochekina	S 03°45'21.5"	W 071°37'29.6"
26/07/2016 -11h25	San Antonio	S 03°48'18.6"	W 071°34'25.4"
26/07/2016 -11h55	Alto Monte	S 03°52'01.8"	W 071°22'38.9"
26/07/2016 -11h59	San Isidro	S 03°51'39.5"	W 071°20'35.5"
26/07/2016 - 12h45	San Pablo	S 04°00'59.6"	W 071°06'07.5"
26/07/2016 - 13h34	Chimbote	S 03°55'40.8"	W 070°47'10.4"
26/07/2016 - 14h29	Caballo Cocha	S 03°53' 49"	W 070°30'19.1"
26/07/2016 - 16h15	Porto Alegria	S 04°06'39.7"	W 070°03'13.8"
26/07/2016 - 16h41	Porto de Santa Rosa	S 04°13'04.7"	W 069°57'19.1"
26/07/2016 - 17h25	Porto de Tabatinga	S 04°13'44.4"	W 069°56'41"

Figure 5: Data and hours with GPS coordinates of the locations in Peru, with graphics of average temperatures the river's surface and environment and later wind direction between the Brazilian towns of Tabatinga to São Paulo de Olivença on 2016, 27 to 28 July.

The speed and wind direction can be observed (Figure 5) (Left) with geo-referencing of the locations where water samples were taken in Peru. (Center) Average Temperature Charts (environment and the river's surface, Peru - July 2016) (Right) Wind direction between the locations of Tabatinga to São Paulo de Olivença (AM / BRAZIL) – 2016, July.

The total average temperature of the surface of the river, in Peru, is higher -by approximately 2 °C, which is a normal condition since this part of the river is the beginning and the distance to Manaus is the triple of this extension, where the average is finished. The wind direction seen in the graphic is a feature of many changes of direction caused by the river curves.

IV. CONCLUSION

This time on the Amazon River in the period of July 26-30, 2016 was within the climate normality in the Western Amazon. The observed period was of river drought from Iquitos (Peru) and Manaus (Brazil) already in the Central Amazon. We cannot yet define the actual present climate because of the first phase of the Expedition, although preliminary results already indicate the real Amazon climate tendency in the drought period. The authors hope to portray the profile from this period in details in December, when the estuary of the river reaches the mouth in the Atlantic Ocean.

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