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Updating of the Köppen and Thornthwaite and Mather (1955) climate classification system for the Southern Amazonas

Atualização do sistema de classificação climática de Köppen e Thornthwaite e Mather (1955) para o sul do Amazonas

Paulo André da Silva Martins[1], Carlos Alexandre dos Santos Querino[2], Juliane Kayse Albuquerque da Silva Querino[2], Marcos Antônio Lima Moura[3], Dorisvalder Dias Nunes[4], Nadja Gomes Machado[5], Marcelo Sacardi Biudes[6]

[1]Departamento de Geografia, Universidade Federal de Rondônia (UNIR), Porto Velho, RO, Brasil.
[2] Programa de Pós Graduação em Ciências Ambientais (PPGCA), Universidade Federal do Amazonas (UFAM), Manaus, AM, Brasil.
[3]Instituto de Ciências Atmosféricas, Universidade Federal de Alagoas (ICAT-UFAL), Maceió, AL, Brasil.
[4]Departamento de Geografia, Universidade de Rondônia (UNIR), Porto Velho, RO, Brasil.
[5]Instituto Federal do Mato Grosso (IFMT), Cuiabá, MT, Brasil.
[6]Instituto de Física, Universidade Federal de Mato Grosso (UFMT), Cuiabá, MT, Brasil.
E-mail: carlosquerino@ufam.edu.br (CASQ); julianekayse@ufam.edu.br (JKASQ); malm@ccen.ufal.br (MALM); dorisval@unir.br (DDN); nadja.machado@blv.ifmt.edu.br (NGM); marcelo@fisica.ufmt.br (MSB).
E-mail para correspondência: martins_silvaandre@yahoo.com.br

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Resumo: Os Sistemas de Classificação Climática (CCS) desempenham um papel importante na definição dos limites geográficos e de zonas agroclimáticas. Assim, o objetivo principal deste trabalho foi determinar e avaliar a classificação climática de Köppen e Thornthwaite e Matter (1955) para a mesorregião Sul do Amazonas. Os dados foram coletados ao longo de 10 anos (abril de 2008 a abril de 2018) pelas estações meteorológicas automáticas do Instituto Nacional de Meteorologia (INMET) instaladas nos municípios de Humaitá, Apuí, Manicoré, Boca do Acre e Lábrea, estado do Amazonas, Brasil. Os resultados mostraram que o CCS de Köppen apresentou o mesmo tipo e subtipo de clima para toda a região analisada. A classificação de Thornthwaite e Mather (1955) mostrou maior sensibilidade à variação climática térmica e hídrica, totalizando 4 (quatro) tipos e 5 (cinco) subtipos de clima considerando as informações geradas pelos respectivos balanços hídricos como déficit e excedente hídrico, evapotranspiração real e potencial, que pode servir como subsidio para estudos de terras ou zonas aráveis. Por outro lado, a classificação de Koppen indicou resultados mais generalistas e que se adequam melhor a macroescala. Desta maneira, a classificação climática de Thornthwaite e Mather (1955) demonstrou melhor precisão do que o método de Köppen para a região de estudo.

Palavras-chave: Amazônia; Clima; Déficit hídrico.

Abstract: *The Climate Classification Systems (CCS) play an important role to define the geographic boundaries and agroclimatic zone. Thus, the main aim of this paper was to determine and evaluate the Köppen and Thornthwaite and Matter (1955) climatic classification for the Southern mesoregion of Amazonas. The data have been collected throughout 10 years (April 2008 through April 2018) by the National Meteorological Institute (INMET) automatic weather stations installed in the municipalities of Humaitá, Apuí, Manicoré, Boca do Acre, and Lábrea, Amazonas State, Brazil. The results have shown that Köppen's CCS has presented the same type and subtype of climate, to the entire analyzed region. Thornthwaite and Mather's (1955) classification showed greater sensitivity to thermal and water climate variation, totaling 4 (four) types and 5 (five) climate subtypes considering the information generated by the respective water balances such as water deficit and surplus, real and potential, which can serve as a subsidy for studies of land or arable areas. On the other hand, the Koppen classification indicated more general results that are better suited to the macroscale. In this way, the climate classification of Thornthwaite and Mather (1955) showed better accuracy than the Köppen method for the study region.*

Keywords: *Amazon; Climate; Water deficit.*

1. Introduction

The climate is described by the averaged atmospheric conditions in a certain region and it is modeled by the interaction of solar radiation, atmospheric circulation, and geographic conditions (NASCIMENTO *et al*., 2016; RAHIMI *et al*., 2019). The climate conditions are responsible for directly affecting many productive sectors, influencing from the seeding up to harvest (DOURADO NETO *et al*., 2010; WHEELER *et al*., 2013). The knowledge of the climate pattern is also crucial to subsidize the implantation and planning of the industries and transport, besides fomenting information to many different kinds of science, such as hydrology, architecture, biology, and medicine (MITCHELL *et al*., 2004; DE CARVALHO *et al*., 2010).

For decades, plenty number of techniques for climate classification was used to identify the types of climate around the world (JACOBEIT, 2010; GALLARDO *et al*., 2013). Those techniques try to explain the spatial and seasonal variability of meteorological variables such as rainfall and air temperature (DE CASTRO *et al.,* 2007; ANDRADE JUNIOR *et al*., 2010). Hence, climate classification models have been presented as the main tool to describe the climate characteristic of a certain region (WHEELER *et al*., 2013).

The Classification Climate System (CCS) defines the geographic boundaries of different types that occur around the world (CUNHA *et al*., 2009). The CCS is broadly used in agroclimatic studies, delimitation of agricultural zones, irrigation, zoning of forests species illnesses, and changes in the biomes (FERNANDEZ *et al*., 2017; MARTINS *et al*., 2018).

One of the most used CCS around the world is Köppen, which considers the natural vegetation linked to the monthly average data of air temperature and rainfall (ROLIM *et al*., 2007; REBOITA *et al*., 2015). Köppen's method is largely used due to the facility of its applicability and interpretation of the results either in its original or modified format (MARTINS *et al*., 2018). However, few studies foment the information related to the efficacy of this CCS to the agroclimatic or agrometeorological studies, which brings the necessity to search for another CCS that better presents the climate and hydric pattern, such as Thornthwaite and Mather (1955) (ARAÚJO *et al*., 2012; LOPES *et al.,* 2016).

The Thornthwaite and Mather CCS (1955) use the climate hydric balance (CHB). It is considered, for the tropical region, one of the best tools for the climate characterization, because it allows obtaining information related to the local or regional hydric availability, through the calculus of the soil moisture indexes used to define the climate homogeneity indicators (MITCHELL *et al*., 2004; NÓBREGA *et al*., 2010).

When comparing both CCS, it is observed that Thornthwaite and Mather (1955) have better accuracy to detect the climate limits, in other words, it has a better sensibility to the climatological variable changes such as air temperature and rainfall, being more appropriate than Köppen CCS to agricultural and agroclimatic applications, mainly in regions nearby the Equator parallel such as the Amazonian region (KOTTEK *et al*., 2006).

Legal Amazonia is composed of nine Brazilian States, among them Amazonas State, which is characterized to be the largest state in Brazil (1.559.168 Km^2 area). Historically, Amazonas State stands out as the lowest deforestation index among the states of the Legal Amazonia. Although, it has been negatively reported around the world about the repercussion of the increasing of the deforestation as well as the burning. However, the real deforestation has not been so elevated when compared to the years of 1995 and 2004, when the rates had crossed over 25 thousand km^2, and in 2005 and 2015, when the numbers of heat focus reach 15 thousand (VAN DEN HURK *et al*., 2018).

The major accumulation of deforestation and burning was in the Southern mesoregion of the Amazonas States, where it is concentrated in seven of the ten municipalities with the highest rates of deforestation and burnings in the entire state. The mesoregion was responsible for 84% of the total deforestation and burnings in the Amazonas State in 2019 with a significant increase when compared to former years (SANTOS NETO *et al*., 2020).

The way of use and occupation of the soil through the advance of the livestock, wood exploitation, and agriculture are the main ones responsible for the rise of the deforestation and, consequently, for the increase in the burnings (GALVÃO *et al*., 2000; SALATI *et al*., 2006; PAVÃO *et al*., 2014).

When the natural soil cover is changed, many deleterious effects are noticed, such as the increase of the sensible heating flux and, consequently, the increase in the air temperature (FEARNSIDE, 2010; NOBRE *et al*., 2013; BIUDES *et al.,* 2015). This modification interferes with the water vapor transference to the atmosphere, modifying the surface radiation and energetic balance (NOGUEIRA *et al*., 2012; CORREIA *et al*., 2011; PAVÃO *et al*., 2017; MACHADO *et al.,* 2017). In this way, these impacts on energy and hydrological flows can cause changes in precipitation patterns and air temperature, as well as a generalization regarding the climate classification for the entire Amazon, which makes a regional climate reassessment necessary.

Thus, the main aim of this paper was to carry out the climate classification by using the CCS proposed by Köppen and Thornthwaite and Matter (1955) and, afterward, evaluate the differences among them in the Southern Amazonas mesoregion.

2. Material and method

2.1. Study area

The Southern Amazonas mesoregion concentrates ten of the sixty-two municipalities of the state, five of which, Apuí, Boca do Acre, Humaitá, Lábrea, and Manicoré (**Figure 1**), were analyzed because they are the only ones with automatic weather stations installed. The territorial area of the five municipalities totalizing 206.215 Km^2 and they are located in a square delimited by the coordinates 5° 48′ 32″ / 07°30’22” S e 61° 18′ 0″ / 63°01'15" W and altitudes that vary between 32m up to 127m. According to the Brazilian Institute of Geography and Statistic – BIGS (IBGE, 2019), Apuí has the lowest population (21.583 hab) and Manicoré the biggest one (54.907 hab).

The region has a wet period from October to April, a dry period throughout June and August, and May and September are considered transitions wet–dry and dry – wet, respectively (PEDREIRA JUNIOR *et al*., 2018; MARTINS *et al.,* 2019). The average annual air temperature varies between 27 and 25 °C, with monthly maximums and minimums of 36 and 17 °C, respectively, while the relative humidity varies between 85 and 90%, reaching values below 50% during the season. drought (ALVARES *et al*., 2013).

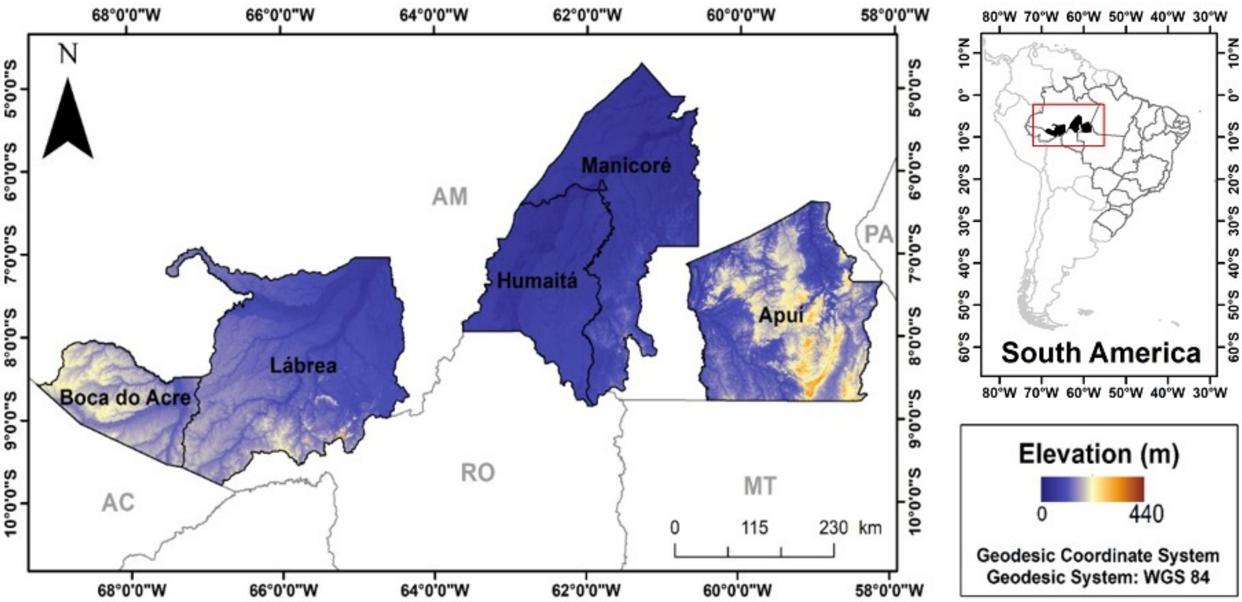

Figure 1: Localization of the municipalities of Humaitá, Manicoré, Lábrea, Boca do Acre and Apuí in the Amazonas Southern mesoregion, Brasil.

2.2. Data

The air temperature and rainfall data had been collected by the automatic weather station (AWS) administered by the Brazilian Meteorological Institute (Inmet) installed in each municipality **(Table 1)**. The data were collected each minute and, afterward, integrated per hour from April 2008 to April 2018 (10 years of data), except Manicoré, which had only eight years of data due to the late installation of the weather station (2010 – 2018).

Table 1: Weather Meteorological Information, Coordinates, and data period of the Automatic Weather Station (AWS) administered by the Brazilian Meteorology Institute – INMET, and installed in each studied municipality.

City	Latitude	Longitude	Altitude (m)	AWS Code (OMM)	Data Period
Humaitá	-7° 55' 25"	-63° 07' 13"	54	81890	2008-2018
Apuí	-7°20' 54"	-59° 88" 85"	157	81893	2008-2018
Manicoré	-5° 78' 85"	-61° 28' 82"	41	81810	2011-2018
Boca do Acre	-8° 77' 68"	-67° 33' 25"	112	81927	2008-2018
Lábrea	-7° 26' 06"	-64° 78' 85"	62	81888	2008-2018

2.3. Thornthwaite and mather climate classification system (1955)

2.3.1. Reference evapotranspiration (ETo)

The Thornthwaite and Mather CCS (1955) use the Climatological Hydric Balance (CHB), which depends on the potential evapotranspiration (PET) (Equation 1) determined by the Thornthwaite's method (1948).

$$PET = 16.(10.\frac{T}{I})^{a} \qquad \text{(Eq.1)}$$

Where T is the monthly average temperature ºC and I is the heat index for the study region (Equation 2). The I depends on the annual pattern of the temperature, integrating the thermal effect of each month in which the "a" exponent (Equation 3) is a function of I (PEREIRA *et al*., 2002).

$$I = (\frac{T}{5})^{1,514} \qquad \text{(Eq. 2)}$$

$$a = 0,675.10^{-6}.I^{3} - 0,771.10^{-4}.I^{2} + 1,792.10^{-2}.I + 0,49239 \qquad \text{(Eq. 3)}$$

The value of PET represents the total amount of the evapotranspiration that would occur in the thermal condition of a standard month of 30 days, and each day with 12 hours of photoperiod (N). Hence, the ETp must be corrected (COR) in the function of N and in the function of the number of days in the period (NDP) (Equation 4).

$$COR = \left(\frac{N}{12}\right)\left(\frac{NDP}{31}\right) \qquad \text{(Eq. 4)}$$

2.3.2. Climate classification

The climate classification was carried out by using the monthly and annual hydric deficit and excess, both derived from the hydric balance. Thus, it was used the hydric index - Hi (Equation 5), dryness index – Di (Equation 6), and moisture index - Mi (Equation 7) (Cunha et al., 2009). Afterward, it was obtained the real evapotranspiration (ETR), soil water storage (ARM), hydric deficit (DEF), and the hydric excess (EXC) on a monthly scale (PEREIRA *et al*., 2002).

$$Hi = CAD.\frac{EXC}{PET} \qquad \text{(Eq. 5)}$$

$$Di = CAD.\frac{DEF}{PET} \qquad \text{(Eq. 6)}$$

$$Mi = Hi - 0,6 . Di \qquad \text{(Eq. 7)}$$

2.3.3. Available water capacity (AWC)

The Available Water Capacity (AWC) in the soil, used in this study, was proposed by Rossato (2001) through remote sensing, which detected different AWC zones for each region of Brazil **(Table 2).**

Table 2: Available Water Capacity (AWC) in the soil, covering the municipalities of Humaitá, Manicoré, Lábrea, Boca do Acre, and Apuí, all of them located in the Southern mesoregion of Amazonas State.

Municipalities	Available Water Capacity (CAD) (mm)
Humaitá	200
Lábrea	150
Boca do Acre	150
Manicoré	150
Apuí	100

2.4. Köppen climate classification system

The Köppen CCS is commonly used by the academic and scientific community. This system is composed of keys, which vary according to the annual average of the air temperature (Tair), the air temperature of the coolest and hottest months, the annual average of the rainfall as well as the months with the highest or lowest rainfall amount (TERASSI *et al*., 2016).

The climate types of Köppen classification are carried out from the definitions of the groups; the first capital letter is the indicator of the type of the climate; the second and the third letters are the indicators of the climate subtype.

3. Results and discussion

3.1. Meteorological variables

The rainfall in all municipalities here studied had presented three different periods: the wet (from October to April), the dry (from June to July), and, the wet to dry transition month (May) and the dry to wet transition month (September) (**Figure 2**).

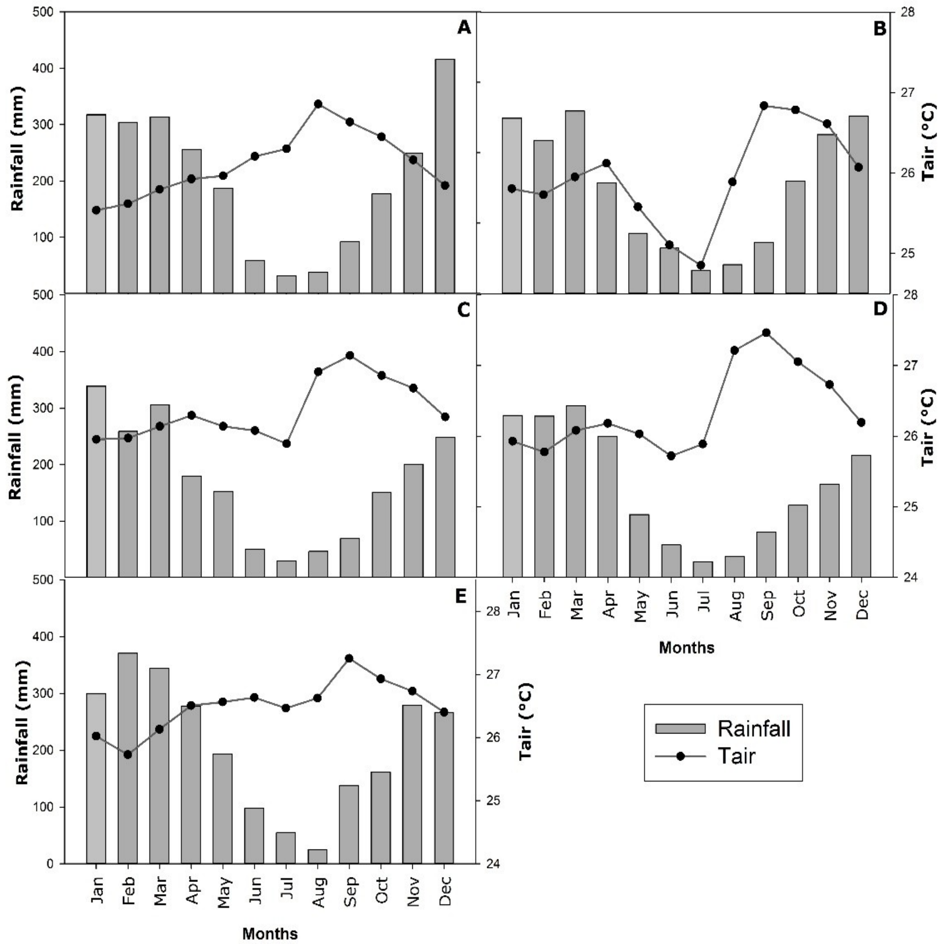

Figure 2: Monthly average of rainfall (PPt), and air temperature (Tair) from 2008 to 2018 in the municipalities that integrate the Southern Amazonas mesoregion. **A-** Apuí, **B-** Boca do Acre **C-**Lábrea **D–** Humaitá **E-** Manicoré.

The wet period was responsible for 90% of the entire annual rainfall, while the transition period reached 6% and the dry one only 4%. The rainiest period (rainfall over 300 mm months^{-1}) happened throughout four months (December through March). On the other hand, July stood out as the driest month with a monthly total of rainfall under 50 mm months^{-1} for all studied municipalities.

The regional wet period comprehends the seasons of summer and fall and it is caused mainly by the actions of the South America Monsoons System, by the occurrence of the South Atlantic Convergence Zone (SACZ) that is characterized by a cloudy region acting from Amazonia up to the Southeastern of Brazil and by the Bolivian High Pressure (BH) system that is an anticyclone in high levels of the troposphere (200 hPa) (DANTAS, 2000; REBOITA *et al.*, 2010). The BH results from the warmest moisture air convergence in low levels of the atmosphere and, consequently, from the coolest air divergence in high levels (CHECHI *et al.*, 2012). All these systems are responsible to provoke a huge volume of rainfall in the entire area of their actuation.

The dry period happens during the winter season. It is characterized by high temperatures and low humidity.

3.2. Köppen climate clasification

The Köppen climate classification system presented only one climate type: tropical with monsoon climate (Am) (**Table 3**). The Am climate has specific characteristics such as the coldest month average temperature above 18° C, no characteristic low winter temperatures, and annual precipitation over potential evapotranspiration (PET). The annual PETs were: Apuí - 1039.53 mm, Manicoré - 1604.85 mm, Lábrea 1601.55 mm, Humaitá - 1602.45 mm and Boca do Acre - 1525.60 mm (**Figure 3**). According to the indicator that relates to the climate type, the Mesoregion presents a monsoon climate, which is formed by average annual precipitation higher than 1500 mm, a fact that occurred in all studied municipalities, together with the well-defined dry period with the amount of rainfall lower than 60 mm.

Table 3: Köppen Climate classification for the Southern Amazonas mesoregion.

Municipalities	1st key (Climatic group)	2nd key (Climatic group)	3rd key (Climatic group)
Apuí	A (Tropical)	m (Monsoon climate)	Only group (B, C e D)
Boca do Acre	A (Tropical)	m (Monsoon climate)	Only group (B, C e D)
Lábrea	A (Tropical)	m (Monsoon climate)	Only group (B, C e D)
Humaitá	A (Tropical)	m (Monsoon climate)	Only group (B, C e D)
Manicoré	A (Tropical)	m (Monsoon climate)	Only group (B, C e D)

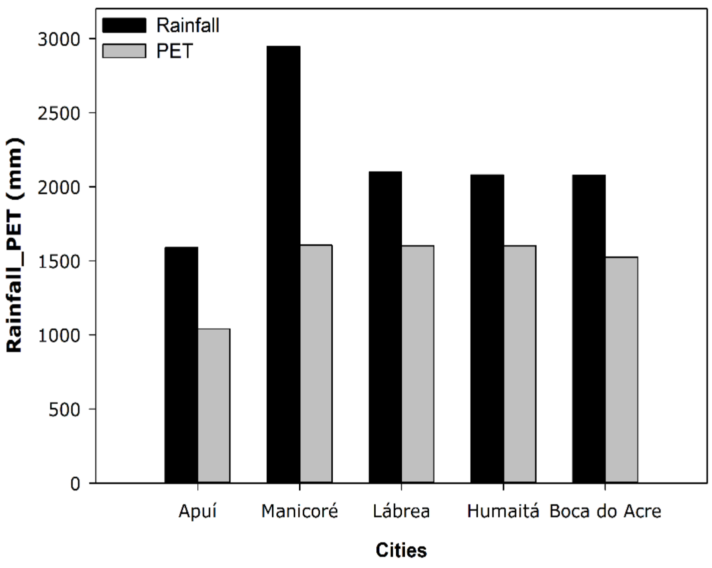

Figure 3: Annual precipitation totals (PPt) and potential evapotranspiration (PET) from 2008 through 2018 in the municipalities that integrate the Southern Amazonas mesoregion: Apuí, Manicoré, Lábrea, Humaitá e Boca do Acre.

Although the studied municipalities are latitudinally close, the Köppen climate classification did not take into account the specificities of each location, such as the relief and altitude. Thus, it is considered very comprehensive and its use is more appropriate on a Macroclimatic scale. This behavior was also observed by Rolim *et al.,* (2007) when they compared the two climatic classifications in the state of São Paulo and concluded that the meteorological variables contained in the Köppen methodology were not able to differentiate several climate types only with the annual average values of precipitation and monthly average temperatures. As in studies carried out in Ceará and Minas Gerais, similar patterns were observed between the classifications, with the Thorntwaite and Matter method indicating more accurate results in relation to the water balance, while the Köppen classification is more effective on larger scales (MEDEIROS AND HOLANDA, 2019; MARTINS *et al*., 2018).

3.3. Thornthwaite and Mather climate classification system (1955)

3.3.1. Thornthwaite and Mather climatic water balance (1955)

All the municipalities have presented water excess: Apuí - 651.0 mm, Boca do Acre - 747.8 mm, Humaitá - 718.1 mm, Lábrea - 716.6 and Manicoré - 1609.3 mm. Water surplus was concentrated in all the municipalities from December to April, the summer season, the period with the highest rainfall. Hence, the higher the rainfall, the greater the water excess (ROSSATO *et al*., 2004).

The month of October in the municipalities of Manicoré and Lábrea showed that there is neutrality without the existence of deficit or excesses since there is a withdrawal followed by replacement.

The Climatic Water Balance (BHC) recorded an average annual Water Deficiency (DEF) of 101.5 mm in Apuí, 195.1 mm in Boca do Acre, and 240.7 mm in Humaitá, 218.4 mm in Labrea and 267.9 mm in Manicoré. In all the municipalities, water deficiencies occurred during the transition period (May and September) and dry season (June to August).

The annual Real Evapotranspiration (ETR) in Apuí was of 938.0 mm, in Boca do Acre of 1330.5 mm, in Humaitá of 1361.7 mm, in Labrea of 1383.1 mm and in Manicoré of 1336.9 mm. The months with the lowest ETR are arranged in three periods: transition (May and September), dry (June to August), and rainy (October).

The annual values of Potential Evapotranspiration (PET) follow the precipitation cycle, i.e., the highest values occur in the rainy season and the lowest in the dry period. The highest PETs were recorded in the summer, which occurred due to the greater availability of solar energy, which, together with soil moisture, are major conditioning factors for the PET (CORREIA *et al*., 2011; SANTOS NETO *et al*., 2020).

The PET represents the necessary rainfall and the process of water loss to the atmosphere through a surface, it will always be greater than the ETR, since it is always calculated under optimum conditions, without water restriction, and with a vegetated border, reducing the advection process. Thus, PET aims to meet the needs of evaporation and perspiration, while ETR does not require special conditions, as it constitutes the loss of water from a natural surface under any conditions of humidity and vegetation cover (CAMARGO AND CAMARGO 2000; MARENGO *et al*., 2013).

The BHC showed that deficit, excess, withdrawal, and replacement occur in all municipalities. The periods of excess in all of them include six months of the year (November to April), except for Lábrea, which extends until May. The excess is verified in the rainy season of the region, and summer-autumn seasons, so the amount of precipitation that occurs in the months of water excess surpasses the value of available water capacity (CAD). The highest water excess values in Apuí were 200 mm in December, 190 mm in Boca do Acre, 220 mm in Humaitá, and 600 mm in Manicoré, all in March, in contrast to Lábrea where the highest occurrence was 250 mm in January.

The water deficit occurs from May to September in Apuí, Boca does Acre, and Manicoré, June to September in Lábrea, and from May to October in Humaitá. The water deficit values did not vary much in the maximums in all cities being below 100 mm. The concentrations of these values occurred in the middle of the dry season between July and August, due to less precipitation. The water deficit is related to the amount of water that the plant needs and its storage in the soil, that is, in the months that comprise the dry period when the greatest deficits occur, the use of irrigation is necessary due to the low availability of water.

Water withdrawal occurred at practically the same periods of water deficit from May to October. Withdrawal represents the amount of water that the plant extracts from the soil via the root system, seeking at greater depths its water support. The onset of precipitation also marks the beginning of replacement. It occurs between November and January. This period is considered short due to the large amounts of precipitation in the region that, once started, provide a rapid replacement of soil CAD.

3.3.2. Climatic classification

The climate in Humaitá was classified as B_4WA'a'. In Apuí, B_2 r B'$_4$ a '. Lábrea obtained a climate rating B_2 W A'. Manicoré AWA'a' while Boca do Acre obtained B_3WA'a' (**Table 4**). Some climate rating indices were within the same range in all municipalities. The water index (Ih) and annual potential evapotranspiration were always above 1140 mm, whereas summer PET was less than 48% compared to annual. The differences occurred in the aridity indices (Ia).

Thornthwaite and Mather's (1955) CCS offers greater accuracy when compared to Köppen CCS, as it considers criteria such as annual and summer potential evapotranspiration, water index, humidity index and mean values of air temperature and precipitation, as well as their values in the classification intervals arranged in the water balance (ANDRADE JUNIOR *et al*., 2005; ROLIM *et al*., 2007; CHEN *et al.,* 2016; TERASSI AND TOMMASELLI 2016).

The larger subdivision of climate types and subtypes makes the Thornthwaite and Mather CCS (1955) more efficient than the Köppen one (PEREIRA *et al*., 2002; VAN DE HURK *et al*., 2013). When comparing both SCCs, it is observed that there was no equivalence between them in the determination of climate types and subtypes for the Southern Amazon mesoregion. Kuinchtner *et al.,* (2001), Feddema (2005) Rolim *et al*., (2007), Grundstein (2008), Gallardo *et al.,* (2013), Souza *et al.,* (2013) state that the non-equivalence of the Köppen classification system is expected since each classification system has different assumptions in the assessment of climate types.

Therefore, some information about climate elements such as temperature and precipitation, as well as values derived from water balance such as PET, ETR, DEF, EXC provide support for the analysis. In this context, the Thornthwaite and Mather (1955) CCS was able to more efficiently describe the information generated in the water balance, especially the one concerning air temperature (HORIKOSHI *et al*., 2007; HAYLOCK *et al*., 2008; KLAIR *et al*., 2014; RIBEIRO *et al*., 2016).

Table 4: Thornthwaite and Mather (1955) climate classification for the Southern Amazonas mesoregion.

Municipalities	Index of humidity (Iu)	Index of dryness (Ia)	Annual ETp	ETp in Summer (%)
Humaitá	**B_4** Humid $80 \leq Iu < 100$	**W** Moderate water deficiency in winter. 16,7-33,3	**A'** Megathermic ≥1140	**a'** <48%
Apuí	**B_2** Humid $40 \leq Iu < 60$	**r** Little or no water deficiency in winter. 0 - 16,7	**B'$_4$** Mesothermal 997-1140	**a'** <48%
Lábrea	**B_2** Humid $40 \leq Iu < 60$	**W** Moderate water deficiency in winter. 16,7-33,3	**A'** Megathermic ≥1140	**a'** <48%
Manicoré	**A** Super-humid $100 \leq Iu$	**W** Moderate water deficiency in winter. 16,7-33,3	**A'** Megathermic ≥1140	**a'** <48%
B. do Acre	**B_3** Humid $60 \leq Iu < 80$	**W** Moderate water deficiency in winter. 16,7-33,3	**A'** Megathermic ≥1140	**a'** <48%

Pereira *et al.,* (2002) Fernandes *et al.,* (2009) Silva *et al.,* (2014) explain the numerous utilities of BHC that can be used in the agroclimatic zoning of certain regions, serving as parameters for the calculation of potential water demand in irrigated crops, sowing dates and knowledge of water regime.

The small variations in the precipitation regimes (Ppt) and air temperature (Tair) were also found in studies conducted in Rio de Janeiro, where the model proposed by Thornthwaite and Matter (1955) brought better results since it presented a larger range of variations ranging from one mesothermal super-humid climate to the megathermic dry sub-humid climate. On the other hand, the Köppen classification presented only three varieties of climate classification: Hot, humid, and altitude tropical for the study region (SANTANA *et al*., 2005).

In a comparative analysis of the two CCSs for the state of Rio de Janeiro, Galvani (2004) showed that the Thornthwaite and Matter (1955) CCS can characterize the geographic space with greater specificity by using the water balance. This tool was more adequate with variations in the thermal and water regime because it considers not only the water inlets and outlets of the systems but also the stored in the soil profile, usable in the many processes that occur in the soil-atmosphere system.

4. Conclusion

The model proposed by Thornthwaite and Mather (1955) has proven to be accurate to measure the variations in thermal and water regimes, accounting for four climatic types, ranging from humid to super-humid, and five subtypes, from megatermic to mesothermal, with differences in the types of humidity with moderate water deficiencies in winter.

Köppen CCS proved to be a generalist and its efficiency stands out only on the macroscale, with a low ability to find larger climate types; therefore, it should not be used in studies to determine agroclimatic zones.

However, with the climate classification system of Thornthwaite and Matter (1955) it was possible to efficiently verify the largest division of climate types, seeing that it can answer the information generated by the respective water balances such as water deficit and surplus, potential and real evapotranspiration, also serving for the studies of arable land or zones.

Rainfall measurements (PPt) in all municipalities presented three distinct periods: rainy (October to April), dry (June to August) and rainy to dry transition (May) and dry to rainy transition (September).

Air temperature (Tair) has not to show large differences in mean values. The lowest temperatures occurred in the fall/winter transition. The municipality of Boca does Acre has recorded the lowest averages, while the period with the highest air temperature (Tair) occurred in spring and Humaitá had the highest value among all of them.

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