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[ID: 35141] STUDY OF CLIMATOLOGY AND THERMAL COMFORT ON RIO DE JANEIRO CITY: PRELIMINARY ANALYSIS FOR 2016 OLYMPIC GAMES

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INTRODUCTION

Weather conditions analysis has proven to be an useful tool when directed specifically to sports. For instance, running and football would hardly be considered as weather-dependent [5]. In these activities one of the major themes in weather applied to sports comes up: the thermal comfort of the athlete [3]. Some studies indicate that the evaluation of bio-climatological conditions and thermal comfort in endurance sports has fundamental importance in training programs, nutritional plan and also for improving evaluation of race strategies [4]. **Objective: develop climatological analysis and thermal comfort assessments directed to sports and applied to Rio de Janeiro city, in Brazil. It is also expected that the results obtained might help the development of products and services to be used on 2016 Olympic Games, held at Rio de Janeiro city.**

METHODS

Area of Study: Rio de Janeiro city (Figure 1), with special focus on the places that will held outdoor competitions. According to the official website of the 2016 Olympic Games, outdoor sports will be held at Copacabana and Maracanã areas (numbers 2 and 3, respectively, on Figure 1d). In order to compose the climatology, two weather stations in that area were selected (denoted by red dots in Figure 1c), since they are the only stations that have at least 10 years worth of useable data.

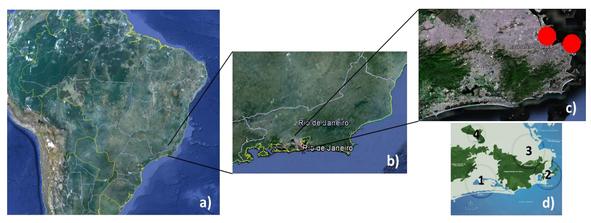

Figure 1. Location of Rio de Janeiro State (b) related to Brazil (a), and Rio de Janeiro city (c) related to the state. It also includes the venues map of 2016 Olympic Games (d), in which numbers from 1 to 4 indicate the name of the competition zones.

Period of Study: was chosen according to the data availability in both stations (2003 to 2014 – 12 years), and also to the months of interest to the Games (July – Acclimation; August – Olympics; September – Paralympics), named as JAS period. Monthly means of air temperature, wind velocity, humidity and surface pressure, for 00, 06, 12 and 18Z were calculated for each station. The means between mean parameters of the two stations were the analyzed results.

Thermal Comfort Analysis: different thermal comfort indices were calculated - Effective Temperature (ET) and Effective Temperature related to the wind (ETv), using equations of the literature [6]; Physiological Equivalent Temperature (PET), Predicted Mean Vote (PMV) and Standard Effective Temperature (SET), using Rayman's Model [2]. The thermal comfort analysis was based on the grade of physiological stress of the indices and classified according to a color scale, as presented in Table 1.

Grade of Physiological Stress	Initials	ET/ET$_V$	PET	PMV
Extreme Cold Stress	ECS	< 13	< 04	< -3,5
Strong Cold Stress	SCS	13 to 16	04 to 08	-3,5 to -2,5
Moderate Cold Stress	MCS	16 to 19	08 to 13	-2,5 to -1,5
Slight Cold Stress	SCS	19 to 22	13 to 18	-1,5 to -0,5
Comfortable	CFT	22 to 25	18 to 23	-0,5 to 0,5
Slight Heat Stress	SHS	25 to 28	23 to 29	0,5 to 1,5
Moderate Heat Stress	MHS	28 to 31	29 to 35	1,5 to 2,5
Strong Heat Stress	SHS	31 to 34	35 to 41	2,5 to 3,5
Extreme Heat Stress	EHS	> 34	> 41	> 3,5

Table 1. Distribution of comfort/discomfort zone according to ET, ETv, PET and VMP. Colors and initial scales are shown in order to facilitate the classification.

RESULTS AND DISCUSSION

The climatological analysis consisted of identifying the main weather systems that affect the Rio de Janeiro area during July, August and September. According to the literature [1] they are **South Atlantic Subtropical High (SASH)** and **Frontal Systems**. The following weather conditions are expected during the study period: **low precipitation**, mainly in July and August; **precipitation events related to frontal systems** (cold fronts); **low cloudiness**, with some increase noticed throughout September; **mild temperatures**, with pronounced declines after the passage of cold fronts; **relatively lower air humidity**; **little effect of sea/land breeze**. Table 2 presents the mean meteorological parameters calculated as defined in Methods section.

Month	T (°C)	RH (%)	MSLP (hPa)	V* (m/s)	Prec** (mm)
July	22,1	72,7	1017,1	1,0	48,1
August	22,7	70,3	1016,4	1,3	23,8
September	23,2	70,2	1014,8	1,4	44,5

Table 2. Monthly means (July, August and September) of air temperature (T) in °C, relative humidity (RH) in %, mean sea level pressure (MSLP) in hPa, wind velocity (V) in m/s and accumulated precipitation (Prec) in mm. (*) 2013 and 2014 not included for one of the station, because of absence of data; (**) Mean accumulated precipitation calculated just for one station, that had the complete data serie.

Some features resulting from the indices are first discussed, followed by the results from the thermal comfort analysis. ETv showed better results during night time, whereas in the mornings and afternoons its values were much lower than the other indices. PET and PMV were consistent with each other with respect to the thermal comfort, but when they differed from each other, the physiological stress of PMV was considered and the value of PET was taken just as a thermal sensation.

This is because PET is highly influenced by meteorological parameters which in turn affect thermoregulation processes of the body, such as temperature and wind [4]. SET had good evaluation to an individual in normal activity, but when a high level of activity was presented, its values were very much lower than the other indices. One of the main reasons for this is the high impact of skin temperature on SET, although it might decrease during physical activity in a cold environment.

Tables 2, 3 and 4 summarize the thermal comfort analysis on the JAS period, respectively, for 00, 06, 12 and 18Z (03, 09, 15 and 21 local time). The grade of physiological stress, classified according to Table 2, is given to situation of normal and high level activity, whereas for the former an average thermal sensation is presented, called Apparent Temperature (AT). It is the simple mean of ET, ETv, PET and PMV, except for 12 and 18Z, when ETv is neglected for not being representative.

Activity Level	AT (°C)	Physiological Stress	
	00 Z		
Normal	18	SCS	CFT
High	-	SCS	CFT
	06 Z		
Normal	16	MCS	SCS
High	-	SCS	CFT
	12 Z		
Normal	22	CFT	SHS
High	-	CFT	SHS
	18 Z		
Normal	25	SHS	
High	-	SHS	MHS

Table 3. Thermal comfort analysis for Rio de Janeiro city on July.

Activity Level	AT (°C)	Physiological Stress	
	00 Z		
Normal	19	SCS	CFT
High	-	CFT	
	06 Z		
Normal	16	SCS	
High	-	SCS	CFT
	12 Z		
Normal	24	SHS	
High	-	SHS	
	18 Z		
Normal	26	MHS	
High	-	MHS	

Table 4. Thermal comfort analysis for Rio de Janeiro city on August.

Activity Level	AT (°C)	Physiological Stress	
	00 Z		
Normal	19	CFT	
High	-	CFT	
	06 Z		
Normal	17	SCS	
High	-	SCS	CFT
	12 Z		
Normal	25	SHS	
High	-	MHS	
	18 Z		
Normal	27	MHS	
High	-	MHS	

Table 5. Thermal comfort analysis for Rio de Janeiro city on September.

CONCLUSIONS

Results related to climatological analysis for Rio de Janeiro city, on the period of Olympic Games, show that **situations of extreme weather, as storms or extremely low temperatures, are not expected** (in the analyzed period the coldest temperature reached was about 11°C). Over JAS period occurrence of rainfall in Rio de Janeiro is due to cold fronts passage, but the **accumulated precipitation is the lowest of all year**. The **relative humidity also reaches the lowest levels on JAS**, due to predominant circulation of SASH, nevertheless the comfortable condition is maintained by the sea and the bay in the region.

Thermal comfort assessment for Rio de Janeiro city in average situation **did not indicate for JAS period extreme discomfort both for heat and cold**. Nights and early mornings tend to present slight cold stress, which is softened in August and September, while mornings and afternoons range from comfortable situation to moderate heat discomfort in the period. **September afternoons are more susceptible to moderate heat stress** than the other months, which in case of intense physical activity can even be strong.

A climatological analysis similar to that developed in this work, if released in advance to competing delegations of a sport event could **contribute to substantial improvement preparation and practice of the athletes**. Training under similar weather conditions might improve the athlete's ability to compete and give them more confidence.

REFERENCES

[1] Dereczynski, C. P., Marengo, J., Silva, M. G. A. J., Santos, I. A., 2011. Impactos sobre o meio físico: clima e mudanças climáticas na cidade do Rio de Janeiro, Cap. 2, UFRJ. Rio de Janeiro.

[2] Matzarakis, A., Rutz, F., Mayer, H., 2007. Modelling radiation fluxes in simple and complex environments – application of the RayMan model, Int Journal of Biometeorology.

[3] Perry, A., 2004. Sports tourism and climate variability, Advances in Tourism Climate.

[4] Pezzoli, A., Cristofori, E., Gozzini, B., Marchisio, M., Padoan, J. 2012. Analysis of the thermal comfort in cycling athletes, Procedia Engineering.

[5] Spellman, G., 1977. Marathon running an all-weather sport?, Weather.

[6] Suping, Z., Guanglin, M., Yanwen, E. W., Ji, L., M. 1992. Study of the relationships between weather conditions and the marathon race, and of the meteorotropic effects on distance runners, International Journal of Biometeorology.

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