PRECIPITATION STUDIES FOR RAIN ATTENUATION PREDICTION IN THE AMAZON REGION

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1. Introduction

Rainfall rate is an essential input parameter in the prediction of rain attenuation. Mathematical models used in this prediction are function of precipitation rate distribution at a point in or near to the propagation path. However, such distributions are available for a limited number of locations. A solution to overcome this difficulty is the extrapolation from one point to another one belonging to the same climatic region. In this context, rainfall characteristics of the Amazon region is described in this paper. Rainfall data presented here correspond to preliminary results from a research program on rain attenuation which is being developed under the responsibility of the Military Institute of Engineering with financial support from the National Scientific and Technological Development Council (CNPq).

2. Köppen Climate Classification

The structure of Köppen climatic classification depends on temperature, precipitation and vegetation [1]. Once these meteorological factors can be related to the statistical distribution of rainfall rate, Köppen classification was adopted in this paper. According to this classification, the climate of Amazon region is a tropical rainy type (A) where 3 subtypes can be identified:

a) Rainy equatorial (Af) – with a large annual rainfall (over 2000 mm) and practically no dry season;
b) Monsoon tropical (Am) – the annual rainfall is equal to or larger than Af, but there is a short dry season (one to three months);
c) Wet-and-dry tropical (Aw) – where the rain and dry seasons are well defined.

Figure 1 shows the geographical limits of these climatic subtypes and the rain gauge network implemented in the Amazon region. Tipping bucket gauges with 0.1 mm capacity and 1 minute integration time are being used. Typical average monthly rainfall amount (mm) and temperature (^{0}C) from 3 selected locations (Boa Vista – Aw, Santarém – Am and Cruzeiro do Sul – Af), are shown in Figure 2 [2]. It is clear from this figure that the subtype Am is a transition climate between Af and Aw. However, as it will be commented in the next Section, due to higher rainfall rates in the rainy season, its effect on system availability is quite important.

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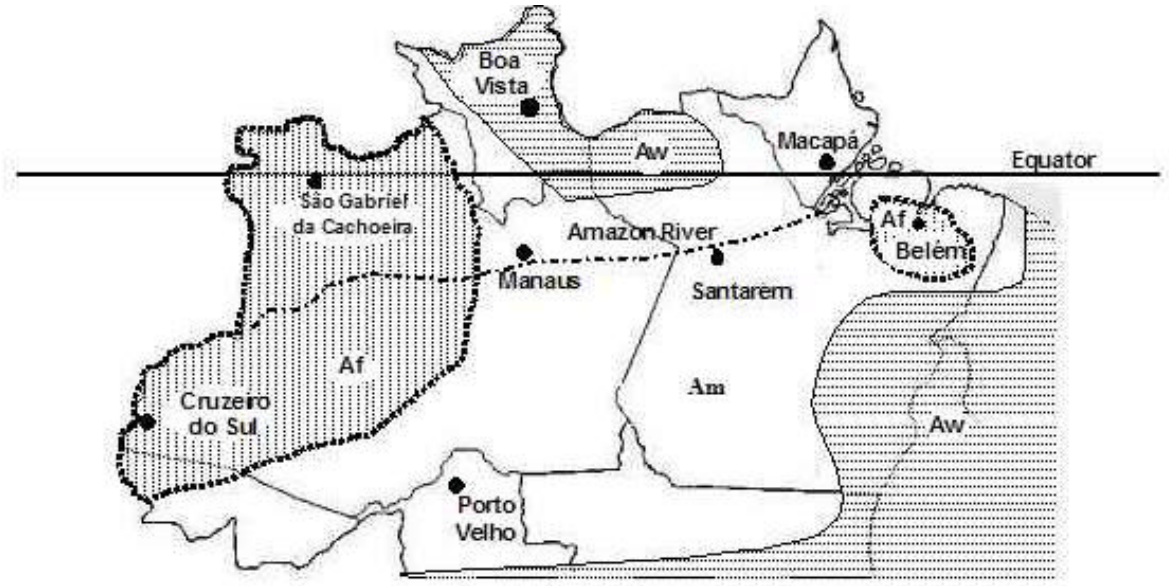
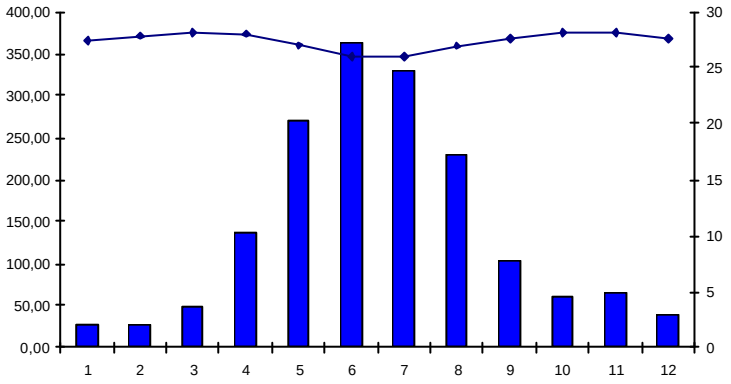
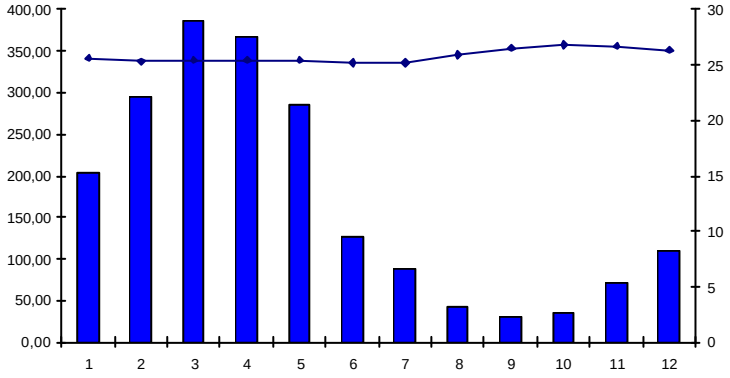


Figure 1 – Köppen climate classification in the Amazon region.



(a)



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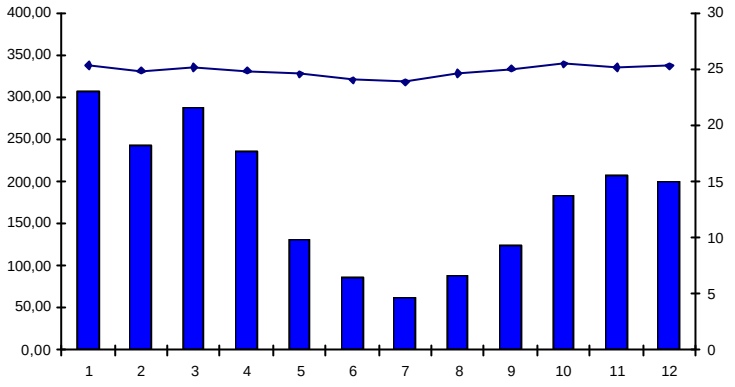

(c)

Figure 2 – Typical average monthly rainfall amount (mm) and temperature (^{0}C) in the Amazon region. (a) Aw - Boa Vista (S 2.79 W 54.72); (b) Am – Santarém (S 2.50 W 54.72); (c) Af – Cruzeiro do Sul (S 7.61 W 72.68).

3. Rainfall Characteristics in the Amazon Region

Figures 3 and 4 show the annual and the monthly cumulative distributions for the above cited locations. As expected, based on the total annual amount of rain (over 2000 mm for both Cruzeiro do Sul and Santarém), there is no significant difference in the annual cumulative distribution of rainfall rate between Af and Am subtypes. On the other hand, in the case of Boa Vista (subtype Aw) lower rain rates are observed.

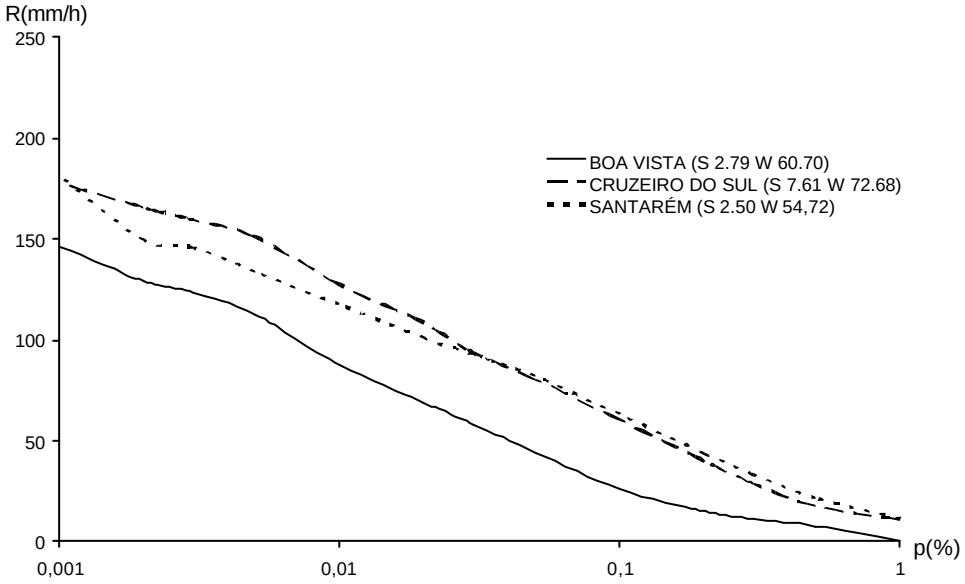

Figure 3 – Annual rainfall rate distributions.

The statistical behaviour is not the same when considering worth month distributions [3]. For relatively low rainfall rates, i.e. in the range from 1 to 0.1 percent of time, distributions for Af and Am subtypes are almost the same. This behaviour is of interest for low availability systems as, for instance, satellite broadcasting reception. However, from 0.01

to 0.001 percent of time, higher rainfall rates are observed in the subtype Am. In this subtype there is a large difference between dry and rainy seasons. When planning high availability communication systems in this climate, this behaviour should be take into account. A similar conclusion appears in the case of subtype Aw. Possibly, automatic transmission power control (ATPC) can be used as mitigation technique to compensate for such high rainfall rates.

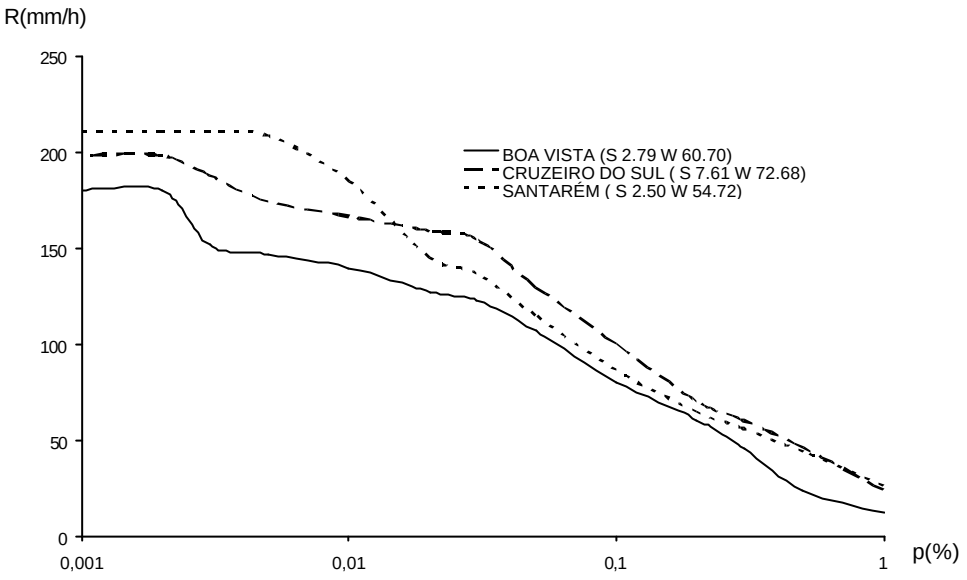

Figure 4 – Worst-month rainfall rate distributions.

4. Concluding Remarks

Based on Köppen climate classification, rainfall characteristics of Amazon region were described in this paper. In spite of being classified as a tropical rainy climate, 3 subtypes were identified (Af, Am and Aw). Under the practical point of view, the importance of each subtype depends on the particular aspect being considered. Although, regarding the annual cumulative distribution, each one follows the expected behaviour, the same is not true for the worst month distribution. In this context, different procedures should be taken into account when planning low or high availability communication systems.

5. References

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[2] www.worldclimate.com, accessed on 02/21/2005.
[3] ITU-R Recommendation P.581-2: "'The concept of worst-month", International Telecommunication Union, Geneva, 1994.