Rain Intensity Statistical Processing and Comparison with ITU-R Recommendations

Václav KVIČERA, Martin GRÁBNER, Michal HLAVATÝ

Lab. of Microwave Links, TESTCOM, Hvožďanská 3, 148 01 Praha 4, Czech Republic

kvicera@testcom.cz

Abstract. *Rain intensities have been measured since February 1992 by means of a heated siphon raingauge. Rain intensity data gathered over 11-year period were statistically processed, cumulative distributions of rain intensities obtained, and relations between them were compared with ITU-R recommendations.*

Keywords

Microwave communication, absorption fading, rain intensity.

1. Introduction

Rain intensities have been measured at TESTCOM in Prague, Czech Republic since February 1992 by means of a heated siphon raingauge. Raingauge records were read by a graphic tablet, data were stored on PC hard disc and statistically processed over the 1992-2002 11-year period. Cumulative distributions of average 1-minute rain intensities for individual years and an average year (AY), cumulative distributions of average *n*-minute (n = 1, 2, 5, 10, 15, 20, 30, 40, 60, 120, 240, 360) rain intensities for AY, cumulative distributions of average 1-minute rain intensities for the worst months of individual years and for the average worst month (AWM) were obtained by statistical processing of rain intensity data. The relation between cumulative distributions of rain intensities for AY and for an average season (AS), and the relation between AY and AWM were derived.

2. Cumulative Distributions

2.1 Cumulative Distributions of Rain Intensities for Individual Years

Great year-to-year variability was observed among yearly cumulative distributions of average 1-minute rain intensities. For percentage of time between 0.0001 and 1, the maximum difference between rain intensities reaches up to 60 mm/h for 0.0005 percentage of time. The maximum rain intensity observed was 133 mm/h in 1993.

2.2 Relation between Cumulative Distributions of Rain Intensities for AY and AS

In the Czech Republic, siphon raingauge measurements usually start about 15 May and finish on about 15 October due to cold weather. Till now, cumulative distribution of rain intensities for winter season was only estimated. Now we had at disposal measured cumulative distributions of rain intensities for both summer and winter seasons and we could assess how the inaccuracy raised. The differences between measured cumulative distribution and recalculated distribution from summer season basis to 1-year one, i. e. if the influence of cold seasons is not taken into account, are smaller than 1 mm/h. The cold season only slightly affects cumulative distribution of rain intensities for the percentage of time greater than 0.004, i.e. for rain intensities smaller than 50 mm/h. It means that the contribution of cumulative distribution of rain intensities for cold season to cumulative distribution of average 1-minute rain intensities for the whole year is not very significant in our climatic conditions.

2.3 Cumulative Distributions of Rain Intensities for Individual Worst Months

Great year-to-year variability was observed among cumulative worst month distributions of average 1-minute rain intensities. For percentage of time between 0.001 and 1, the maximum difference between rain intensities is up to 60 mm/h for 0.003 percentage of time. The observed maximum rain intensity was 133 mm/h in July 1993.

2.4 Comparison of Obtained Distributions for AY and for AWM with Relevant Recommendation ITU-R

The obtained cumulative distributions of average 1-minute rain intensities for AY and AWM are given in Fig. 1. The probability of rain occurrence for AY is 3.94%, for AWM it is 6.17%. The calculated cumulative distributions in accordance with [1] are also shown in Fig. 1. The calculated average 1-minute rain intensities for AY are greater than the measured ones for percentage of time smaller than 0.00015. For percentage of time between 0.0003 and 0.03, the calculated average 1-minute rain intensities are slightly smaller than the measured ones. The maximum difference is about 15 mm/h. The calculated average 1-minute rain intensities are up to 2 mm/h greater than the measured ones for percentages of time greater than 0.03. Similarly, the calculated average 1-minute rain intensities for AWM are greater than the measured ones for percentage of time smaller than 0.0014. For percentage of time between 0.0014 and 0.14, the calculated average 1-minute rain intensities are slightly smaller than the measured ones. The maximum difference is about 20 mm/h. The calculated average 1-minute rain intensities are up to 2 mm/h greater than the measured ones for percentage of time > 0.14.

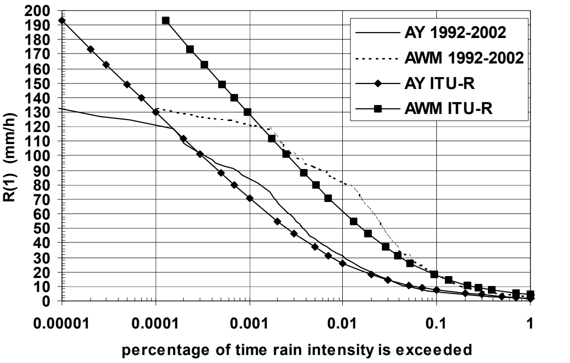

Fig. 1. Obtained and calculated cumulative distributions of average 1-minute rain intensities for AY and AWM.

2.5 Relation between AY and AWM

The obtained dependence of percentage of time of the average year PAY on percentage of time of the average worst month PAWM for the same average 1-minute rain intensities can be approximated for 1 mm/h ≤ $R(1)$ ≤ 133 mm/h by (1):

$$P_{AY} = 0.31595 \times P_{AWM}^{1.19344} \ [\%] \qquad (1)$$

with a correlation coefficient R = 0.99694. The obtained dependence agrees with [2] very well.

2.6 Cumulative Distributions of Average *n*-minute Rain Intensities for AY

The obtained cumulative distributions of average n-minute (n = 1, 2, 5, 10, 15, 20, 30, 40, 60, 120, 240, 360) rain intensities for AY are drawn in Fig. 2. The dependence between $R(n)$ and $R(1)$ can be approximated by (2):

$$R(1) = a \,.\, R(n)^{b} \ \text{[mm/h]}. \qquad (2)$$

The obtained coefficients a, and b, correlation coefficients R and validity for calculations are given in Tab. 1.

3. Conclusions

Rain intensity data measured over an 11-year period were statistically processed. Cumulative distributions of average 1-minute rain intensities for AY, AS, and AWM were obtained. The obtained differences between the recalculated average 1-minute rain intensities for AY from the distribution for AS and the measured ones were found be smaller by about only 1 mm/h due to omitting cold seasons. Both the calculated rain intensities for AY and for AWM in accordance with ITU-R recommendation are slightly underestimated in comparison with the measured ones. This might be balanced by a longer observation. Generally speaking, good agreement with the corresponding recommendation ITU-R was found.

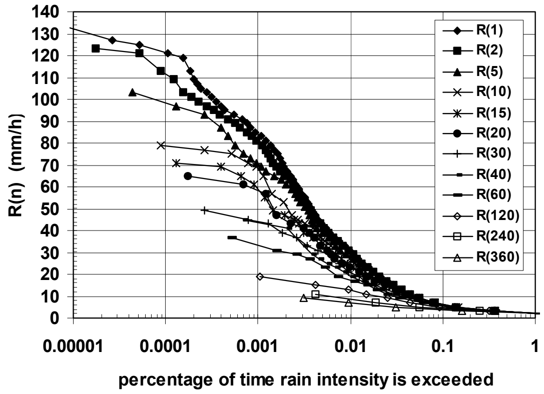

Fig. 2. Obtained cumulative distributions of average n-minute rain intensities for AY.

Conversion	a	b	R	% of time from - to	$R(n)$ (mm/h) from - to
$R(2) \Rightarrow R(1)$	0.9895	1.012	0.99987	0.00005 - 1	121.4 - 1.3
$R(5) \Rightarrow R(1)$	0.9700	1.037	0.99960	0.0001 - 1	100.8 - 1.3
$R(10) \Rightarrow R(1)$	0.9404	1.069	0.99899	0.0002 - 1	77.5 - 1.3
$R(15) \Rightarrow R(1)$	0.9208	1.094	0.99838	0.0003 - 1	69.6 - 1.3
$R(20) \Rightarrow R(1)$	0.9257	1.106	0.99837	0.0005 - 1	62.9 - 1.3
$R(30) \Rightarrow R(1)$	0.8772	1.165	0.99460	0.0007 - 1	46.2 - 1.3
$R(40) \Rightarrow R(1)$	0.9300	1.151	0.99689	0.002 - 1	42.3 - 1.3
$R(60) \Rightarrow R(1)$	0.8428	1.253	0.99598	0.001 - 1	36.3 - 1.3
$R(120) \Rightarrow R(1)$	0.7515	1.476	0.98864	0.002 - 1	18.1 - 1.3
$R(240) \Rightarrow R(1)$	0.8251	1.584	0.99436	0.01 - 1	9.4 - 1.3
$R(360) \Rightarrow R(1)$	0.8730	1.830	0.99218	0.007-1	7.7 - 1.3

Tab. 1. Coefficients a, and b, correlation coefficients R and validity for approximation (2).

Acknowledgements

The Ministry of Education under the grant No. OC 280.001 and TESTCOM under the task No. 9-331-1960 “Time Variability, Dynamic and Space Features of Characteristics of Electromagnetic Waves for Advanced Telecommunication Systems” have supported the research.

References

[1] Rec. ITU-R P.837-3 *Characteristics of precipitation for propagation modelling.* ITU, Geneva, March 2003.

[2] Rec. ITU-R P. 841-2 *Conversion of annual statistics to worst-month statistics.* ITU, Geneva, March 2003.