Proceedings of ISAP'04, Sendai, JAPAN

THE BEST METHOD FOR RAIN ATTENUATION DISTRIBUTION PREDICTION BASED ON RESULTS OF TRIALS OBTAINED AT 38 GHz AND 58 GHz

Vaclav KVICERA(1), Martin GRABNER(1), Petr CEJKA(1), Ondrej FISER(2)
(1)TESTCOM
Hvozdanska 3, 148 01 Praha 4, Czech Republic
(2) IAP AS CR
Bocni II/1401, 141 31 Praha 4, Czech Republic
kvicera@testcom.cz

1. Introduction

Radiowave propagation experimental research at TESTCOM has been focused primarily on attenuation due to hydrometeors (rain, hail, fog, snow) at 38 GHz and 58 GHz. Attenuation due to hydrometeors has been measured on three paths for several years.

The records of received signal level obtained from three paths were processed statistically over the 3-year period of observation December 2000 - November 2003. These records were also compared with concurrent meteorological situations [1] that made it possible to distinguish among attenuation due to rain, snow, fog, rain with snow and rain with hail. Rain intensities were measured at TESTCOM for the same period. Both cumulative distributions of attenuation due to rain and cumulative distributions of average 1-minute rain intensities for the average worst month and the average year over a 3-year period were used as input values for selecting the best method for rain attenuation distribution prediction.

The results obtained for individual combination of paths as well as periods of the average year and the average worst month can be found in Tables below. The results are discussed and the conclusions generalised that may be used for testing in other climatic conditions.

2. Trial results

Geographical locations of experimental paths are shown in Fig. 1. Rain intensities have been measured by means of a heated siphon raingauge at TESTCOM. The obtained cumulative distributions (CDs) of rain intensities for the average year as well as for the average worst month over the 3-year period of observation December 2000 - November 2003 are drawn in Fig. 2.

TESTCOM has measured attenuation due to hydrometeors at 38 GHz on V polarisation on the path Strahov – TESTCOM (path A). The path length is 9.3 km, the working frequency is 38 319.75 MHz, polarisation V. Antennas having diameter of 0.6 m (G = 45 dB) have been used. The recording margin is 52 dB. The obtained CDs of attenuation due to rain for the average year (AY) as well as for the average worst month (AWM) over the 3-year period of observation are plotted in Fig. 3.

The second path, where attenuation due to hydrometeors at 38 GHz on V polarisation is measured, is the path Uvaly – TESTCOM (path B). The length of this path is 15.2 km, the working frequency is 38 491.25 MHz, polarisation V. Antennas having diameter of 0.6 m have been used. The recording margin is 60 dB. The obtained CDs of attenuation due to rain for AY as well as for AWM over the 3-year period of observation December 2000 - November 2003 are given in Fig. 4.

TESTCOM and the Institute of Atmospheric Physics of the Academy of Sciences of the Czech Republic (IAP AS CR) have been carrying out a common experimental research in the frequency band 58 GHz on an experimental path between IAP AS CR and TESTCOM (path C). Nokia MetroHopper equipment with special offset antennas manufactured at TESTCOM, having diameter of 60 cm, have been used. The path length is about 850 m, the frequency used is 57 650 MHz, polarisation V. The obtained CDs of attenuation due to rain for AY as well as for AWM over a 3-year period of observation are shown in Fig. 5.

ISBN: 4-88552-207-2 C3055©IEICE

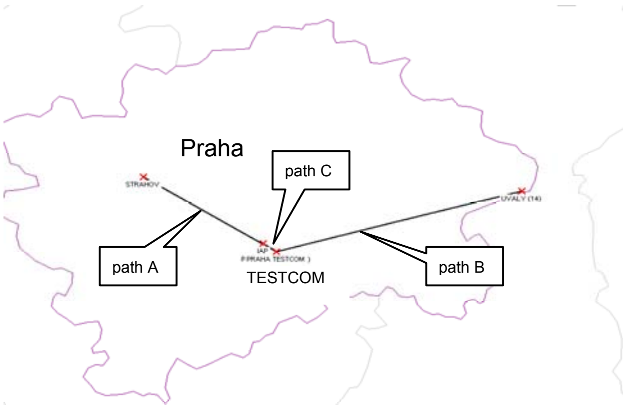

Fig. 1 Topology of paths

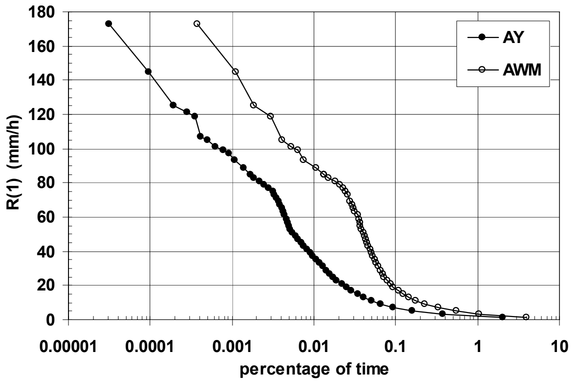

Fig. 2 Obtained cumulative distributions of rain intensities at TESTCOM for average year and average worst month

3. Results of testing and discussion

Testing criteria for comparing different prediction methods are described in detail in Recommendation ITU-R [2]. The test variable values were calculated for 0.001, 0.002, 0.003, 0.005, 0.01, 0.02, 0.03, 0.05, 0.1, 0.2, 0.3, 0.5, and 1 percentage of time. The validity of methods is described by the number X/Y. X is the calculated number of test variables over decades, Y is the maximum possible number of test variables. If $X<Y$, it means that the method is not valid over whole period of given decades. The better is the prediction method, the smaller are the values of the statistical parameters. Only the first method with the highest validity was always selected. The results obtained are summarised in Tables 1-4.

Table 1 The best methods obtained for individual paths and their statistical parameters for given individual periods and individual decades

Path	Period	Decades	The best method	Validity	$\overline{\rho}_V$	$\overline{\mu}_V$,	$\overline{\sigma}_V$,
A	AY	0.01 - 1	USA Ib	8/9	9.1875	-0.0394	0.0830
		0.1 - 1	USA Ia	5/5	6.9309	0.0048	0.0691
	AWM	0.1 - 1	Costa-Assis	5/5	6.4348	0.0210	0.0608
B	AY	0.01 - 1	ITU Rec.530-10 Ib	7/9	12.8012	0.0106	0.1276
		0.1 - 1	CCIR 1986 Rep.338-5 Ia	5/5	8.9067	-0.0102	0.0885
	AWM	0.1 - 1	Misme-Fimbel	4/5	3.6415	0.0172	0.0321
C	AY	0.001 - 1	EXCELL	12/13	22.7517	-0.0660	0.2177
		0.01 - 1	EXCELL	9/9	10.6190	0.0461	0.0956
		0.1 - 1	EXCELL	5/5	13.6728	0.0964	0.0969
	AWM	0.01 - 1	EXCELL	8/9	23.6979	-0.1274	0.1998
		0.1 - 1	EXCELL	5/5	8.5581	-0.0026	0.0855
		0.01 - 1	USA Ia	41/54	24.2290	-0.1399	0.1978
		0.1 - 1	USA Ia	29/30	23.5251	-0.1320	0.1947

Table 2 The best methods obtained for individual paths and their statistical parameters for AY and AWM together and individual decades

Path	Period	Decades	The best method	Validity	$\overline{\rho}_V$	$\overline{\mu}_V$,	$\overline{\sigma}_V$,
A	AY, AWM	0.01 - 1	USA Ib	13/18	8.3981	-0.0226	0.0809
		0.1 - 1	Costa-Assis	10/10	9.1932	0.0046	0.0918
B	AY, AWM	0.01 - 1	ITU Rec.530-10 Ib	11/18	10.4541	0.0083	0.1042
		0.1 - 1	Misme-Fimbel	9/10	8.0258	-0.0058	0.0800
C	AY, AWM	0.001 - 1	EXCELL	20/26	23.1348	-0.0905	0.2129
		0.01 - 1	EXCELL	17/18	17.9993	-0.0355	0.1765
		0.1 - 1	EXCELL	10/10	11.4058	0.0469	0.1040

Table 3 The best methods obtained for two and three paths together and their statistical parameters for given individual periods and individual decades

Path	Period	Decades	The best method	Validity	$\overline{\rho}_V$	$\overline{\mu}_V$,	$\overline{\sigma}_V$,
A, B	AY	0.01 - 1	USA Ia	15/18	13.5724	-0.0374	0.1305
		0.1 - 1	USA Ia	10/10	8.9509	-0.0433	0.0783
	AWM	0.1 - 1	USA Ia	9/10	12.2946	-0.0014	0.1229
A, B, C	AY	0.001 - 1	USA Ia	27/39	24.9417	-0.1614	0.1902
		0.01 - 1	USA Ia	24/27	22.2887	-0.1325	0.1793
		0.1 - 1	USA Ia	15/15	24.4547	-0.1623	0.1830
	AWM	0.01 - 1	USA Ia	17/27	26.7296	-0.1505	0.2209
		0.1 - 1	USA Ia	14/15	22.4866	-0.0996	0.2016

Table 4 The best methods obtained for two and three paths together and their statistical parameters for AY and AWM together and individual decades

Path	Period	Decades	The best method	Validity	$\overline{\rho}_V$	$\overline{\mu}_V$,	$\overline{\sigma}_V$,
A, B	AY, AWM	0.01 - 1	USA Ia	24/36	13.1078	-0.0239	0.1289
		0.1 - 1	USA Ia	19/20	10.6662	-0.0234	0.1041
A, B, C	AY, AWM	0.001 - 1	USA Ia	44/78	25.6472	-0.1572	0.2027
		0.01 - 1	USA Ia	41/54	24.2290	-0.1399	0.1978
		0.1 - 1	USA Ia	29/30	23.5251	-0.1320	0.1947

It can be seen from Table 1 that different methods were obtained for both the paths A and B for individual decades of AY and AWM. Only the same best method was found for the path C over all decades for both AY and AWM. The same results were obtained for individual paths and AY and AWM period together, as given in Table 2. The comparisons of the measured CDs of attenuation due to rain for both the AY and AWM and the calculated ones in accordance with the results given in Table 1 for the paths A, B, and C are plotted in Figs. 3-5.

Somewhat different are the results when the best method is found for two (A and B) or three (A, B, and C) paths together. In this case, the USA Ia method is the best one either for individual periods of AY and AWM or for AY and AWM together. This can be seen from the results shown in Tables 3 and 4. The comparisons of the measured CDs of attenuation due to rain for both the AY and AWM and the calculated ones in accordance with the USA Ia model obtained in Table 1 for the paths A, B, and C are plotted in Figs. 6-8.

If the best method from Table 4 is used for the calculation of CDs of attenuation due to rain for paths A and B over the periods AY and AWM, the results will be slightly worse than if the best methods from Table 1 are used for the same calculations. The comparison between the measured CDs and the calculated ones should be done in the percentage of time for chosen attenuation. This ratio is about 1.5-2.0 for the best methods from Table 1, contrary to 1.5-3 for the best method from Table 3-4.

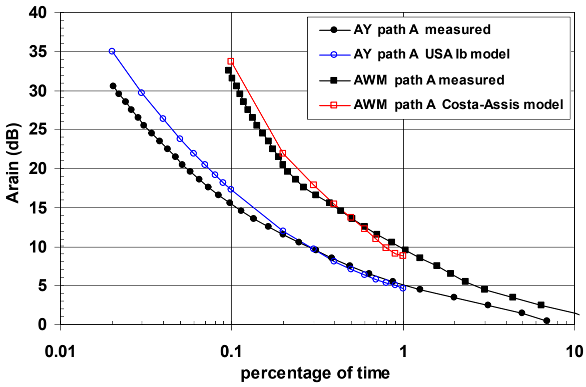

Fig. 3 Measured and calculated distributions of attenuation due to rain at path A for average year and average worst month

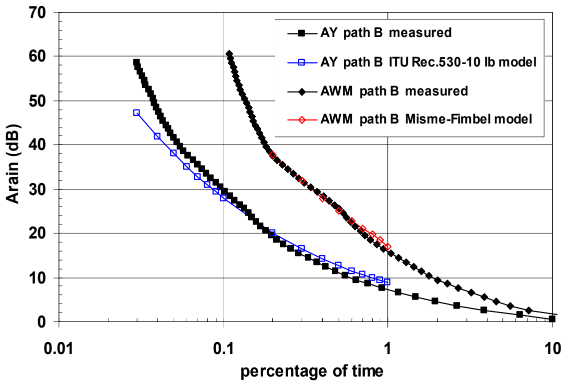

Fig. 4 Measured and calculated distributions of attenuation due to rain at path B for average year and average worst month

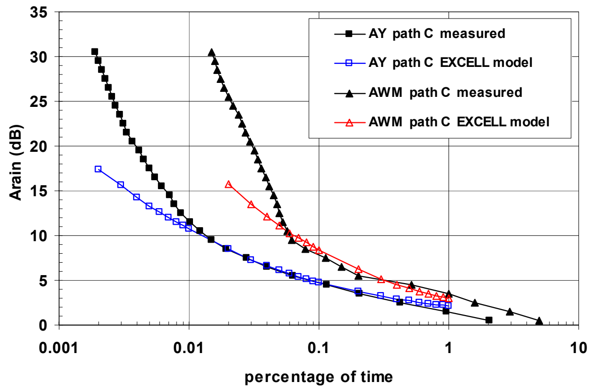

Fig. 5 Measured and calculated distributions of attenuation due to rain at path C for average year and average worst month

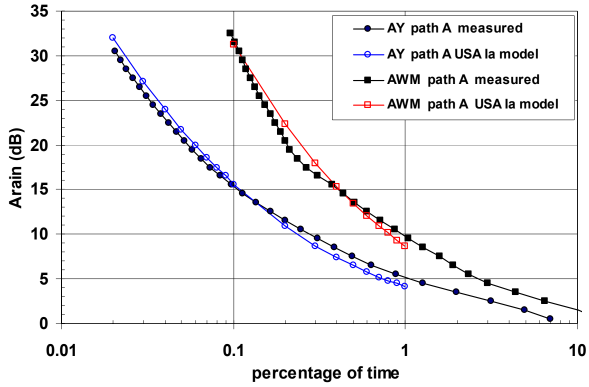

Fig. 6 Measured and calculated distributions of attenuation due to rain at path A for average year and average worst month according to USA Ia model

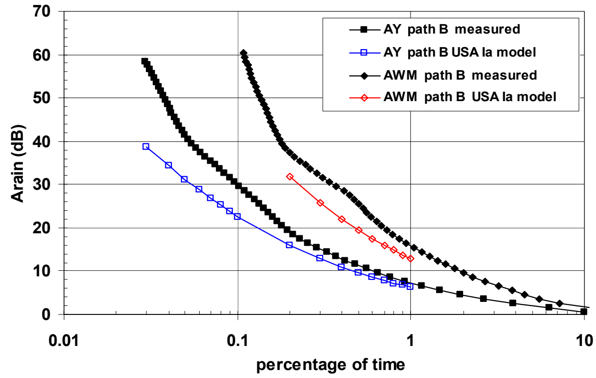

Fig. 7 Measured and calculated distributions of attenuation due to rain at path B for average year and average worst month according to USA Ia model

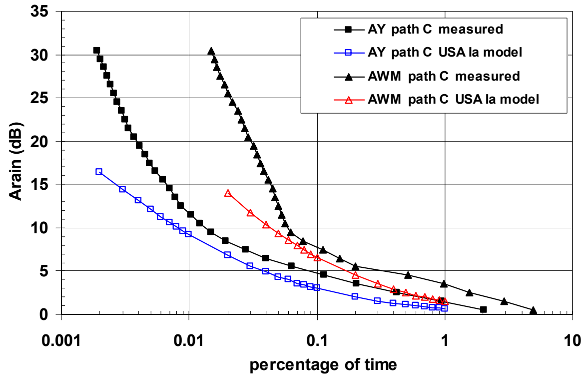

Fig. 8 Measured and calculated distributions of attenuation due to rain at path C for average year and average worst month according to USA Ia model

4. Conclusions

The selection of the best method for rain attenuation distribution prediction is a very complex task. The results obtained should be evaluated according to [2] as well as from the validity point of view. This novel parameter "Validity" has not been used in [2]. In fact, the methods in their majority have some restrictions, e.g. they are not valid over all decades, frequencies, and path lengths. Sometimes it is better to avoid selecting the first method on the list of methods in favour of the further one having the highest validity. A better precision of prediction may also be obtained if assessing the methods over a specific decade only. Extrapolation outside decades of input values is not recommended. A feasible procedure of the selection was illustrated on the examples of data obtained from our long-term measurements in the 38 GHz and 58 GHz frequency bands.

5. Acknowledgement

The processing of data was supported by TESTCOM under task No. 9-331-1212 and testing methods was granted by the Czech Science Foundation under grant No. 102/01/0029 „Performance and Reliability of Advanced Telecommunication Systems using Millimetre Wavelengths“.

6. References

[1] Monthly Meteorological Summaries from Observatory Praha – Karlov, Czech Hydrometeorological Institute, Praha, 2000-2003.
[2] Rec. ITU-R P.311-11: Acquisition, presentation and analysis of data in studies of tropospheric propagation. CD-ROM, Geneva: ITU, September, 2003.