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| Guidelines for testing earth-space prediction methods |

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# 1 Introduction

In its Recommendations, Study Group 3 publishes recommended methods for the prediction of oxygen, water vapour, cloud, rain, scintillation, and total attenuation on Earth-space paths. From time to time, Study Group 3 would like to test these existing prediction methods as well as candidate revisions that are submitted by various administrations and sector members. While the testing procedure is documented in Recommendation ITU-R P.311 and in WP 3M Fascicle [3M/FAS/1](http://www.itu.int/oth/R0A04000007/en) “Testing criteria to be used for comparing propagation prediction methods”, it is not well-defined, which can result in the ambiguous and inaccurate assessment of the prediction accuracy. The purpose of this fascicle is to document the testing procedure in sufficient detail so it is standardized and well-known to all administrations and sector members.

This document is divided into two sections:

1) a description of the pre-processing that must be performed on Table C2\_1 of DBSG3, and

2) a description of testing procedure. It is important to note that this document does not address the testing variable that is used to compare the measured and predicted attenuations. A description of the testing variable for comparing excess and total rain attenuation predictions is provided in Section 4 of the fascicle “Testing criteria to be used for comparing propagation prediction methods”..

# 2 DBSG3 Version

Testing should be performed using the latest version of DBSG3 Table C2\_1 available on the sharefolder are of the WP 3M Correspondence Group CG 3M-2 and the version should be specified in the test results. A copy of this table can be requested from the SG 3 Counsellor.

# 3 DBSG3 Pre-processing

Table C2\_1 of DBSG3 is an aggregate of various excess and total rain attenuation data from beacon, radiometer, and radar measurements over more than 30 years. This data has been reviewed by propagation experts in Study Group 3, and several flags are used to indicate the appropriateness for comparison with the recommended prediction methods. There are currently eight flags defined as follows:

Table 1

Description of flags

| Flag | Description |
| --- | --- |
| FLAG1 | Validity range for rain rate CDF: start time percentage, exponential format in 4 characters, e.g. 3E-3 |
| FLAG2 | Validity range for rain rate CDF: end time percentage, exponential format in 4 characters, e.g. 3E+0 |
| FLAG3 | Validity range for attenuation CDF: start time percentage, exponential format in 4 characters, e.g. 1E-2 |
| FLAG4 | Validity range for attenuation CDF: end time percentage, exponential format in 4 characters, e.g. 5E+0 |
| FLAG5 | Used for single year, multiple years and twin years identification and for type of statistics (‘E’ or ‘T’) to be used for testing.1 The identification of Single-Year (‘S’ in the first character of FLAG5) or Multiple-Year statistics (‘M’ in the first character of FLAG5) are applied only to statistics referring to the same link (i.e. same site, satellite, frequency, elevation, polarization) and to a common observation period. a. An ‘S’ in the first character of FLAG5 indicates a single-year statistic where at least one multiple year statistic is also present in the database (e.g. statistics from 1994/01/01 to 1994/12/31 when the statistic from 1993/01/01 to 1997/12/31 is also available). b. An ‘M’ in the first character of FLAG5 indicates a multiple-year statistic where single-year statistics (or part of them) are also present. c. A ‘0’ (zero) in the first character of FLAG5 indicates single-year statistic where no multiple year statistics are present. d. An “N” in the first character of FLAG5 indicates multiple year statistics when no single year statistics are available. e. A “T” in the first character of FLAG5 indicates the statistic that is similar to an already flagged statistic (e.g., a statistic referring to the same frequency, elevation angle, observation period, but a different polarization angle).2 The second character of this flag denotes if the statistics are to be included in the test of Excess (‘E’) or Total (‘T’) attenuation. |
| FLAG6 | Not currently used |
| FLAG7 | Not currently used |
| FLAG8 | Not currently used |

Step 1: Ignore (or delete) all rain rate entries that are not within the inclusive range between FLAG1 and FLAG2. If either FLAG1 or FLAG2 are blank or 0, ignore (or delete) the whole rain rate curve.

Step 2: Ignore (or delete) all attenuation entries less than 0.5 dB or not within the inclusive range between FLAG3 and FLAG4. If either FLAG3 or FLAG4 are blank or 0, ignore (or delete) the entire attenuation dataset.

Step 3: For Excess attenuation, select the rows whose FLAG5 = 0E or SE. For Total attenuation, select the rows whose FLAG5 = 0T or ST.

Step 4: Limit the weight of any single dataset to a maximum of 10 years.

# 4 Prediction of excess attenuation

Compute the excess (i.e., rain only) attenuation for the selected rain attenuation prediction method using the rain rate data required by the prediction method. If this rain rate data is not present for the case of interest, then ignore that outage probability or row. When testing the current ITU-R model, ignore any specified applicability limits (in terms of frequency, elevation angle, time percentage, etc.) stated in the Recommendations (e.g., ignore the following specified applicability limit stated in Recommendation ITU-R P.618: “The following procedure provides estimates of the long-term statistics of the slant-path rain attenuation at a given location for frequencies up to 55 GHz”).

As an example, for the current ITU-R rain attenuation prediction method that only uses R0.01, the rain rate at the 0.01% outage probability, compute the excess attenuation using the procedure shown in Figure 3, and ignore all rows where R\_01 is blank.

As an additional example, for rain attenuation prediction methods that use the whole probability distribution, *Rp*, compute the excess attenuation using the procedure shown in Figure 4, and ignore all outage probabilities or rows where the prediction method cannot predict the excess attenuation.

Except where noted, all of the parameters shown in Figures 3 and 4 are obtained from the data in DBSG3.

# 5 Prediction of total attenuation

Compute the total (i.e., oxygen, water vapour, cloud, rain, and scintillation) attenuation using the procedure shown in Figure 6, referring to Figure 1, 2, 3 or 4, and 5. When testing the current ITU‑R model, ignore any specified applicability limits (in terms of frequency, elevation angle, time percentage, etc.) stated in the Recommendations (e.g., ignore the following specified applicability limit stated in Recommendation ITU-R P.618: “The following procedure provides estimates of the long-term statistics of the slant-path rain attenuation at a given location for frequencies up to 55 GHz”).

Except where noted, all of the parameters shown in Figures 1, 2, 3 or 4, and 5 are obtained from the data in DBSG3. Refer to the prior paragraph for the prediction of the rain attenuation portion of total attenuation.

Figure 1

Oxygen and water vapour attenuation



Figure 2

Cloud attenuation



Figure 3

Rain attenuation (rain rate at 0.01% level)



Figure 4

Rain attenuation (full rain rate distribution)



Figure 5

Scintillation depth



Figure 6

Total attenuation



# 6 Testing method

Compliance with the specified test methodology must be verified with the appropriate table keeper. The various prediction methods must be tested as follows for the full range of frequencies, elevation angle, and latitudes available in the databank:

– Excess attenuation will be tested, in the probability range between 0.001% and 1%, using both the measured concurrent rainfall rate and the rainfall maps defined in Recommendation ITU-R P.837, and will be compared to (a) the predicted rain attenuation and (b) the sum of the predicted rain attenuation and the cloud attenuation predicted by Recommendation ITU-R P.840.

– Total attenuation will be tested, in the probability range between 0.01% and 10%, using both the measured concurrent rainfall rate and the rainfall maps defined in Recommendation ITU-R P.837.

In addition to these tests, excess attenuation must be tested using the measured concurrent rainfall rate for the following subsets of the DBSG3 databank:

– Frequency ranges: 1 – 17 GHz, 17 – 35 GHz and 35 – 50 GHz;

– Elevation angle ranges: 0 – 15 deg, 15 – 60 deg, and 60 – 90 deg;

– Latitude ranges (in absolute values): 0 – 38o, 38 – 55o and ≥55°.

# 7 Testing results

The in-force excess and total attenuation prediction methods have been tested in April 2015 using the test variable documented in Section 4 of the fascicle “Testing criteria to be used for comparing propagation prediction methods” and Table C2\_1\_v9, file name C2\_1\_CR\_140908\_v19.csv, with the following results:

Excess Attenuation (Rain Attenuation Only)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 0.001 | 0.002 | 0.003 | 0.005 | 0.01 | 0.02 | 0.03 | 0.05 | 0.1 | 0.2 | 0.3 | 0.5 | 1 |
| Years | 8.0 | 18.8 | 39.8 | 56.4 | 104.9 | 114.0 | 119.8 | 118.8 | 111.9 | 92.1 | 81.1 | 70.4 | 63.7 |
| Mean | -0.032 | -0.090 | -0.164 | -0.142 | -0.111 | -0.086 | -0.066 | -0.037 | -0.021 | -0.076 | -0.107 | -0.116 | -0.176 |
| RMS | 0.180 | 0.283 | 0.287 | 0.262 | 0.228 | 0.230 | 0.221 | 0.222 | 0.253 | 0.293 | 0.336 | 0.377 | 0.453 |
| Sigma | 0.177 | 0.268 | 0.236 | 0.220 | 0.200 | 0.213 | 0.211 | 0.219 | 0.252 | 0.283 | 0.319 | 0.358 | 0.417 |

Excess Attenuation (Rain + Cloud Attenuation)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 0.001 | 0.002 | 0.003 | 0.005 | 0.01 | 0.02 | 0.03 | 0.05 | 0.1 | 0.2 | 0.3 | 0.5 | 1 |
| Years | 8.0 | 18.8 | 39.8 | 56.4 | 104.9 | 114.0 | 119.8 | 118.8 | 111.9 | 92.1 | 81.1 | 70.4 | 63.7 |
| Mean | 0.010 | -0.052 | -0.122 | -0.094 | -0.050 | -0.010 | 0.021 | 0.069 | 0.119 | 0.108 | 0.113 | 0.149 | 0.194 |
| RMS | 0.192 | 0.282 | 0.270 | 0.243 | 0.208 | 0.215 | 0.210 | 0.222 | 0.264 | 0.278 | 0.305 | 0.355 | 0.406 |
| Sigma | 0.191 | 0.277 | 0.241 | 0.224 | 0.202 | 0.215 | 0.209 | 0.211 | 0.236 | 0.256 | 0.283 | 0.322 | 0.357 |

Total Attenuation

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 0.01 | 0.02 | 0.03 | 0.05 | 0.1 | 0.2 | 0.3 | 0.5 | 1 | 2 | 3 | 5 | 10 |
| Years | 29.3 | 40.0 | 46.5 | 51.5 | 58.5 | 58.5 | 59.5 | 59.5 | 59.5 | 58.6 | 56.8 | 54.9 | 59.6 |
| Mean | -0.025 | 0.062 | 0.090 | 0.126 | 0.098 | 0.107 | 0.118 | 0.140 | 0.195 | 0.238 | 0.263 | 0.283 | 0.239 |
| RMS | 0.291 | 0.244 | 0.231 | 0.242 | 0.275 | 0.266 | 0.256 | 0.262 | 0.291 | 0.310 | 0.320 | 0.323 | 0.276 |
| Sigma | 0.290 | 0.236 | 0.213 | 0.206 | 0.257 | 0.243 | 0.227 | 0.222 | 0.217 | 0.198 | 0.182 | 0.157 | 0.139 |

# 8 Contact Information

Administrations with questions about these guidelines can contact Professor Carlo Riva at riva@elet.polimi.it or Mr. Harvey Berger at Harvey.Berger@ngc.com.

# 9 References

“Use of flags”, Section 4 of Status of Databanks, *Annex 8 of WP 3M Chairman’s Report*, Document [3M/224](http://www.itu.int/md/R03-WP3M-C-0224/en), 24 August 2007.

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