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| **Radiocommunication Study Groups** |  |
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| Working Party 3M | |
| FASCICLE | |
| GUIDELINES FOR TESTING EARTH-SPACE PREDICTION METHODS | |

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](http://www.itu.int/rec/R-REC-P.311/en), 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 paragraph 4.2 of Recommendation ITU-R P.311.

DBSG3 Version

Testing should be performed using the latest version of DBSG3 Table C2\_1 published at <http://saruman.estec.esa.nl/dbsg3>, and the version should be specified in the test results. User accounts may be obtained by contacting Antonio Martellucci at the European Space Agency; email: [Antonio.Martellucci@esa.int](mailto:Antonio.Martellucci@esa.int)

DBSG3 Preprocessing

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. 2. 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). 3. An ‘M’ in the first character of FLAG5 indicates a multiple-year statistic where single-year statistics (or part of them) are also present. 4. A ‘0’ (zero) in the first character of FLAG5 indicates single-year statistic where no multiple year statistics are present. 5. An “N” in the first character of FLAG5 indicates multiple year statistics when no single year statistics are available. 6. The identification of Twin-Year (‘T’ in the first character of FLAG5) is applied to a statistic that is almost a duplicate of an already flagged statistic (e.g. a statistic referring to the same frequency, elevation angle, observation period, but a different polarization angle). 7. 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 that are not within the inclusive range between FLAG3 and FLAG4. If either FLAG3 or FLAG4 are blank or 0, ignore (or delete) the whole attenuation curve

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

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.

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.

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. 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

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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



Testing

The in-force excess and total attenuation prediction methods have been tested in June 2013 using the test variable documented in paragraph 4.2.1 of Recommendation ITU-R P.311-13,   
Table C2\_1\_v6, file name C2\_1\_CR\_080902\_v15.csv, and the concurrent measured rain rate exceeding 0.01% contained in Table C2\_1\_v6 as well, with the following results:

Excess Attenuation

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Prob.** | **0.01** | **0.02** | **0.03** | **0.05** | **0.1** | **0.2** | **0.3** | **0.5** | **1** | **2** |
| **Years** | 105.9 | 113.0 | 118.8 | 117.8 | 110.9 | 92.1 | 80.1 | 69.4 | 63.7 | 23.0 |
| **Mean** | -0.13 | -0.11 | -0.09 | -0.07 | -0.05 | -0.11 | -0.15 | -0.17 | -0.24 | 0.02 |
| **RMS** | 0.23 | 0.23 | 0.22 | 0.22 | 0.24 | 0.29 | 0.33 | 0.38 | 0.48 | 0.05 |
| **Sigma** | 0.19 | 0.20 | 0.20 | 0.21 | 0.24 | 0.27 | 0.29 | 0.34 | 0.41 | 0.05 |

Total Attenuation

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Prob.** | 0.01 | 0.02 | 0.03 | 0.05 | 0.10 | 0.20 | 0.30 | 0.50 | 1.00 | 2.00 | 3.00 | 5.00 | 10.00 |
| **Years** | 29.3 | 39.9 | 46.5 | 51.5 | 58.5 | 58.5 | 59.5 | 59.5 | 59.5 | 58.6 | 57.6 | 56.7 | 55.7 |
| **Mean** | -0.02 | 0.06 | 0.09 | 0.13 | 0.10 | 0.11 | 0.12 | 0.14 | 0.19 | 0.24 | 0.26 | 0.29 | 0.05 |
| **RMS** | 0.29 | 0.24 | 0.23 | 0.24 | 0.28 | 0.27 | 0.26 | 0.26 | 0.29 | 0.31 | 0.32 | 0.34 | 0.14 |
| **Sigma** | 0.29 | 0.24 | 0.21 | 0.21 | 0.26 | 0.24 | 0.23 | 0.22 | 0.22 | 0.20 | 0.18 | 0.18 | 0.13 |

Contact Information

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

References

“Use of flags”, Section 4 of Status of Databanks, *Annex 8 of WP 3M Chairman’s Report*,   
Document 3M/224, 24 August 2007.

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