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| **Radiocommunication Study Groups** |  |
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| Working Party 3M |
| FASCICLE  |
| on testing variables used for the selectionof prediction methods |

Scope

The material in this Fascicle is providing the detailed procedures for testing propagation prediction methods as indicated in Recommendation ITU-R P.311-12.

# 1 Testing variable for comparing rain attenuation predictions

Attenuation predictions are generally made for a number of transmission paths at a fixed set of probability levels. Data for comparison of prediction methods are to be tabulated at fixed probability levels, e.g. 0.001%, 0.01% and 0.1% of the year. The ratio of predicted to measured attenuation is calculated for each path. The natural logarithm of the ratios is used as a test variable. To compensate for the effects of contributions from attenuation sources other than rain as well as from measurement inaccuracies, which predominantly affect the lower attenuation values, the logarithm is to be multiplied by a scaling factor for values of measured attenuation of less than 10 dB. This scaling factor is a power function of the measured attenuation. The thus modified test variable closely follows a normal distribution. The mean and standard deviations of the (modified) test variable are then calculated to provide the statistics for prediction method comparison.

## 1.1 Procedure

– For each percentage of time, calculate the ratio of predicted attenuation, *Ap* (dB), to measured attenuation, *Am* (dB), for each radio link:

 *Si*  *Ap,i*/ *Am,i* (1)

 where *Si* is the above ratio calculated for the *i-*th radio link.

– Calculate the test variable:

 *Vi*  ln *Si* (*Am,i* / 10)0.2 for *Am,i*  10 dB (2)

  ln *Si* for *Am,i*  10 dB

– Repeat the procedure for each percentage of time.

– Calculate the mean *V*, standard deviation *V*, and r.m.s. value *V*, of the *Vi* values for each percentage of time:

  (3)

NOTE 1 – (Weighting function). If some measured distributions are multi-year (*n* year) data then calculate the mean *V*, standard deviation *V* , and r.m.s. value *V*, of the *n* *Vi* values (e.g. if average year data from three years of observation are assessed, then use three times the same *Vi* value for each percentage of time).

NOTE 2 – (Assessment over decades of probability levels). For the assessment of prediction methods over decades of probability levels (e.g. from 0.001% to 0.1% of time) calculate the test variable *Vi* values for each percentage of time (preferred values are 0.001, 0.002, 0.003, 0.005, 0.01, 0.02, 0.03, 0.05, and 0.1), take into account a weighting function and calculate the mean  standard deviation  and r.m.s. value  of all these *Vi* values over the required decades of probability levels.

In the comparison of prediction methods, the best prediction method produces the smallest values of the statistical parameters. It is to be noted that the logarithmic parameters can afterwards be converted to equivalent percentage parameters. The standard deviation, for example, leads to equivalent upper and lower percentage deviations:

 

which are measures of the spread of the predicted values with respect to the measured ones, normalized to an attenuation value of 10 dB.

The procedure provides a tool not only to assess the performance of the various prediction methods but also to give indications for their improvement. Graphical inspection of the spreads of *Ap* and *Am* values may also give useful information about the relative merits of both experimental data and prediction methods.

Moreover, these statistical parameters may provide some information on the expected spread of actual attenuation values around a predicted one. For this purpose, the above scaling procedure can be used in the reverse direction, i.e. the normalized standard deviation for an attenuation level of 10 dB can be scaled to the standard deviation to be expected at another predicted attenuation level, *Ap* (dB), by the factor (10 / *Ap* )0.2.

It has to be noted that the ultimate limit for the accuracy of any prediction method is the accuracy with which the rain climatic conditions for a given location can be characterized by an assumed point rainfall intensity cumulative distribution.

## 2 Testing method for comparing fade duration predictions

### 2.1 Principle of the method

Fade duration can be described by two different cumulative distribution functions:

1 *P*(*d*  *D**a*  *A*), the probability of occurrence of fades of duration *d* longer than *D*(s), given that the attenuation *a* is greater than *A* (dB).

2 *F*(*d*  *D**a*  *A*), the cumulative exceedance probability, or, equivalently, the total fraction (between 0 and 1) of fade time due to fades of duration *d* longer than *D*(s), given that the attenuation *a* is greater than *A* (dB).

Data for comparison of fade duration prediction methods are tabulated for both a fixed individual fade duration *D* (e.g. 6 s, 180 s or 3 600 s) and for a fixed attenuation threshold *A* (e.g. 3 dB, 10 dB or 25 dB). The ratio of the predicted to the measured fraction of time is calculated for each radio link and the logarithm of this ratio is defined as the test variable. The mean and standard deviation of the test variable are then calculated to provide the statistics for prediction method comparison.

## 2.2 Procedure

*Step 1a*: For prediction methods of the probability of occurrence *P*, calculate the test variable as the natural logarithm of the ratio of predicted probability *Pp*(*d > D|a > A*) to measured probability *Pm*(*d > D|a > A*), for each attenuation threshold *A* and for each fade duration *D* defined in Tables I‑8b and II‑3b, and for each radio link:

  (4)

where:

 ε*P*,*i:* test variable calculated for the *i*-th radio link.

*Step 1b*: For prediction methods of the percentage of fade time *F*, subtract both the predicted fraction of time *Fp*(*d > D|a > A*) and the measured fraction of time *Fm*(*d > D|a > A*) from 1. Calculate the test variable as the natural logarithm of the ratio of these differences, for each attenuation threshold *A* and for each fade duration *D* defined in Tables I‑8c and II‑3c, and for each radio link:

  (5)

where:

 ε*N*,*i:* test variable calculated for the *i*-th radio link.

*Step 2*: For each prediction method, calculate the mean, standard deviation and r.m.s. values of the error *P* or *N* for each individual fade duration and for each attenuation threshold given in Tables I‑8 and II‑3.

If some measured distributions are multi-year (*n* years) data, then calculate the mean, standard deviation and r.m.s. values of the *n* *P*,i or *N*,i values (e.g. if average annual data from three years of observation are assessed, then use three times the same *P*,i or *N*,i value for each fade duration and attenuation).

In the comparison of prediction methods, the best prediction method produces the smallest values of the statistical parameters.

# 3 Testing method for comparing fade slope predictions

## 3.1 Principle of the method

The predicted distribution of fade slope used in this testing method is the cumulative distribution of a fade slope to be exceeded at a given attenuation threshold. It is dependent on attenuation level *A*(*t*), on the time interval length Δ*t* and on the 3 dB cut-off frequency of the low-pass filter which is used to remove tropospheric scintillation and rapid variations of rain attenuation from the signal.

Data for comparison of fade slope prediction methods are tabulated for both a fixed time percentage *P* (from 0.001% to 50%) and for a fixed attenuation threshold *A* (e.g. 3 dB, 10 dB or 25 dB). The ratio of the predicted to the measured fade slope is calculated for each radio link and the logarithm of this ratio is defined as the test variable. The mean and standard deviation of the test variable are then calculated to provide the statistics for prediction method comparison.

## 3.2 Procedure

*Step 1*: For each attenuation threshold *A* and for each fade slope value ζ defined in Table II‑8b, calculate the test variable from the predicted exceedance probability *Pp*(ζ | *A*) and the measured exceedance probability *Pm*(ζ | *A*) for each radio link, as:

  (6)

where:

 *i*: test variable calculated for the *i*-th radio link.

*Step 2:* Calculate the mean, standard deviation and r.m.s. values of the error  for the combination of all experiments, and for each individual fade slope and for each attenuation threshold given in Table II-8b.

If some measured distributions are multi-year (*n* years) data, then calculate the mean, standard deviation and r.m.s. values of the *n* *i* values (e.g. if average annual data from three years of observation are assessed, then use three times the same *i* value for each fade slope and attenuation).

In the comparison of prediction methods, the best prediction method produces the smallest values of the statistical parameters.

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