8
Bibliography


36 ABRAMOWITZ, M.; STEGUN, I. Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables.


CCDF – Complementary Cumulative Distribution Function (see CDF). Let \( F(x \leq X) \) be the CDF of a given random variable, then the CCDF is given by \( 1 - F(x \leq X) \), i.e., \( F(x > X) \).

CDF – Cumulative Distribution Function. The probability of a random variable to have a value less of equal a given value \( X \): \( F(x \leq X) \).

CETUC – Center for Telecommunications Studies of PUC-Rio.

DAU – Data Acquisition Unit. Specialized computer for acquiring and logging of rain and propagation (beacon and/or radiometer) data in Brazilian measurements campaigns. Information is stored in compacted files for transmission over telephonic lines.

First order statistics – statistics related to stationary features of the process. Usually described by the Cumulative Distribution Function. See CDF.

ITU-R – International Telecommunications Union, Radio sector. ITU is an international organism responsible for the release of global recommendations in the telecommunications arena.

MATLAB – MATrix LABoratory. Software tool from MathWorks® for the development of scripts and functions based on input/output data represented by matrices. It has built-in mathematical libraries and was used in this work as a developing environment for computational tools design.

ONERA – Office National d’Études et de Recherches Aérospatiales. The French aerospace research center. Public establishment with industrial and commercial operations, carrying out application-oriented research to support enhanced innovation and competitiveness in the aerospace and defense sectors.
PUC-Rio – Pontifical Catholic University of Rio de Janeiro – Brazil.

Rain-gauge – specially designed equipment for the collection of rain aimed, ultimately, at the measurement of the point rainfall rate. Among many types of rain-gauges, the one used for the measurements reported on this work is of the tipping bucket type. Rain drops fill a bucket with known volume through an aperture with a given area. Knowing that 1 mm of rainfall is equivalent to 1 liter of water per squared meter, one can easily compute the amount of rain (in mm) corresponding to one tip (one tip occurs at each fulfillment of the bucket).

Second order statistics – statistics related to dynamic features of a process. Usually described by the duration and slope of the represented quantity. For attenuation time series, Fade Duration and Fade Slope, as well as the autocorrelation function, are usual descriptions of the dynamics.

Up-time – The net time a measurement set-up is working and properly executing the tasks it is intended to do (equipment is said to be on air). It is usually expressed as a percentage of the total time of the measurements campaign. For example: in an one-year campaign, if the measurement equipments are on air for 340 days, the up-time is about $340/365 \times 100 \approx 93.2 \%$.

WGN – White Gaussian Noise.
Appendix A

Generation of the data structure based on experimental extracted events

A data structure to be used by the microscopic model is generated from the extracted events database. The creation of this structure, exemplified in an extract shown in Table 19, is now explained.

The macroscopic two-state Markov chain channel model provides as output a collection of rain events positions in a synthesized long term time series. Therefore, from the generated time series it is straightforward to obtain the parameter $D$ for each event. To build the microscopic channel model, it is necessary to implement a strategy to associate typical $A_{\text{max}}$ and $D_{\text{peak}}$ for any given $D$. Using as input the experimental events database, an algorithm creates a data structure containing $[A_{\text{max}}, D_{\text{peak}}, D]$ triplets to be used by the microscopic portion of the two-state Markov chain channel model. This algorithm works in the following way.

1. Every isolated experimental event is read from the database and parameters $[A_{\text{max}}, D_{\text{peak}}, D]$ are extracted.
2. Bins of duration $D$ are created, ranging from zero to the maximum value of $D$ in the database. The size of the duration bins is user defined, being 5 minutes the default one.
3. A histogram of events duration is created by the allocation of each rain attenuation event in the proper duration bin.
4. For each duration bin, arranged in columns in the data structure to be output, pairs $[A_{\text{max}}, D_{\text{peak}}]$ are put in lines. In the data structure, instead of saving the $D_{\text{peak}}$ parameter as an absolute value, it is stored as a percentage from the beginning of the event.
5. As a last adjust, $A_{\text{max}}$ values are downgraded to a resolution of 0.1 dB, which is the adopted resolution in all models because of the fact that it is the resolution at which beacon data were recorded.
In the data structure sampled in Table 19, for a selected duration bin (column), each line is a pair $[A_{\text{max}}, D_{\text{peak}}]$ – with $D_{\text{peak}}$ expressed as a percentage from the beginning of the event – to be used for on-demand event generation in the microscopic portion of the MKod model. The first line in the table corresponds to the bin, for example: the second column groups the events having duration between five and ten minutes.

Table 19 – Sample of the data structure created from the experimental events database
Appendix B
RMS error results detailed per thresholds

The color plots shown in Section 6.8 are a sample aimed at the illustration of the improvement such a tool can bring to the analysis of the results and, therefore, to the comparison among the different models, for many thresholds of attenuation, duration and fade slope.

This Appendix presents all the results, grouped in the same way as it is done in Figure 88 (to make it easier for the reader to compare all the models), for each one of three 2nd order statistics analyzed in this work: FDn, FDt and FSc.
Figure 105 – RMS error plots for models comparison (FDn for MOS)
Figure 106 – RMS error plots for models comparison (FDn for RIO)
Figure 107 – RMS error plots for models comparison (FDn for CUR)
Figure 108 – RMS error plots for models comparison (FDn for POA)
Figure 109 – RMS error plots for models comparison (FDt for MOS)
Figure 110 – RMS error plots for models comparison (FDt for RIO)
Figure 111 – RMS error plots for models comparison (FDt for CUR)
Figure 112 – RMS error plots for models comparison (FDt for POA)
Color plot representing eRMS for FSc by attenuation X absolute fade slope MOS

MBa

Color plot representing eRMS for FSc by attenuation X absolute fade slope MOS

MBb

Color plot representing eRMS for FSc by attenuation X absolute fade slope MOS

EMB

Color plot representing eRMS for FSc by attenuation X absolute fade slope MOS

MBb biLN

Color plot representing eRMS for FSc by attenuation X absolute fade slope MOS

EMB biLN

Color plot representing eRMS for FSc by attenuation X absolute fade slope MOS

MKod

Figure 113 – RMS error plots for models comparison (FSc for MOS)
Figure 114 – RMS error plots for models comparison (FSc for RIO)
Figure 115 – RMS error plots for models comparison (FSc for CUR)
Figure 116 – RMS error plots for models comparison (FSc for POA)