F1: Propagation modelling and measurement

The Estimation of the Cumulative Probability Distribution Function of Rainfall Rate as a First Step Towards a Cost Effective Attenuation Prediction Model

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Abstract

At the basis of any attenuation prediction model for satellite communications there is the behaviour of rainfall. Due to the spatial and temporal randomness of rain, the correlation between attenuation and rainfall can only be observed at a statistical level. Therefore, the better the understanding of the statistics of rainfall rate, the better the attenuation models obtained from it.

The statistical modelling of attenuation in an Earth-satellite link requires the joint use of radiometers and satellite beacon receivers. The cost of such a set-up can exceed 40000 US Dollars. In countries with large areas and diverse climates (as is the case of Brazil), the total cost of a widespread coverage is prohibitive. The set-up required for a raingauge does not reach 1000 US Dollars. Therefore, if a model for characterising rainfall-induced attenuation could be obtained from the statistics of rainfall it could greatly improve the mapping of attenuation in countries like Brazil.

The modelling of the cumulative distribution function of rainfall at a given site was achieved by fitting a two parameter Weibull distribution to the empirical cumulative distribution function obtained from the recorded rainfall rates. The Weibull distribution is a generalised form of the exponential distribution and has been found to fit not only rainfall distributions but also the attenuation.

The data used in this study consisted of 93 empirical cumulative distributions of rainfall rate, 73 taken from the ITU-R database and 23 obtained from measurements in several sites in Brazil. The distributions were all obtained from one year of measurements.

The Weibull distribution was found to be an excellent fit to the empirical distributions of rainfall, with explained variances always exceeding 95%. From the statistics of the parameters of the obtained Weibull distribution estimates, it was possible to arrive at the conclusion that the rainfall distributions were in fact Burr Type III. The Burr type III distribution is the result of a Weibull distribution with gamma distributed parameters. This mixture distribution representation makes more physical sense than a single distribution fit since the empirical cumulative probability function of rainfall integrates the effects of stratiform and convective , which are rainfall regimes with totally different dynamics.

This work explores an avenue of research which aims at obtaining a cost effective, yet reasonably accurate, attenuation model and is connected with the overall research objectives and results (extensively published in the literature) of the Propagation Group at the Center for Telecommunication Studies of the Pontifical Catholic University of Rio de Janeiro.