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RAIN ATTENUATION PREDICTION MODELING FOR EARTH-SPACE LINKS BASED ON PHYSICAL CONSISTENCY

Abstract

Recently, some anomalous behaviors have been recognized in most existing rain attenuation prediction models for the earth-space links. In particular, it was reported that the predicted rain attenuation from the ITU-R P.618-9 model could be lower at the location with higher values of both rain rate and rain attenuation. Another anomalous behavior was found when the elevation angle of the earth-space link was increased. Despite the reduction of the slant path length, at high enough elevation angle, the majority of the existing models provided predicted rain attenuation which increased with the increment of the elevation angle. Therefore, these models showed their inconsistency with the physical reality. The source of these behaviors is conjectured to be the model development approach that leads to the overfitting problem.

In this work, we introduce the concept of the physical consistency that can be used to develop a reliable rain attenuation prediction model. A set of physical consistency criteria is proposed as a set of rules that represents a set of normal behaviors of a reliable rain attenuation prediction model. While the current popular approach is to find a model with the best scores, our proposed strategy is to develop a rain attenuation prediction model that possesses reasonable good scores from the model evaluation and also satisfies the proposed set of physical consistency criteria.

A new rain attenuation model is also introduced based on the design of the new correction factor (so called, reduction factor or path adjustment factor). This new model was mathematically proven to satisfy the proposed set of the physical consistency criteria. The parameters of this correction factor were optimized using the available database, including the most recent ITU-R SG3 database and the ITU guideline for testing earth-space prediction methods. Comparing with the existing models, the results from the model evaluation based on the ITU-R P.311 method shows that the scores of this new model with the optimized parameters are on the top lists. Unlike those existing models, our new model exhibits no anomalous behavior, with respect to the proposed set of the physical consistency criteria.