Effective rain rate model for analysing overestimated rain fade in short millimetre-wave terrestrial links due to distance factor

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Abstract

Significant discrepancies have been observed between the measured attenuation induced by rain over mm-wave terrestrial links at very short communication paths and the predicted measurement by ITU-R P.530-18. Recent observations indicate that the rain rate at 0.01 % occurrence used by the ITU-R prediction method does not represent effective rain intensity for less than 1 km of path length, despite its accuracy for paths longer than 1 km. These deviations can be attributed to several factors, such as spatial inhomogeneity, rain cell diameter, and environmental variations. Additionally, sudden changes in the propagation environment, such as wind direction, humidity, and wind speed, contribute to non-uniform rain distributions. Additionally, there is still a lack of comprehensive investigations due to the involved experimental difficulties. Thus, an effective rain rate concept and model are proposed to represent rain intensity variations for short paths to eliminate the need for an effective path length that more accurately predicts rain attenuation at path lengths exceeding 1 km. The proposed model is based on the measured $R_{0.01\ \%}$, short path (less than 1 km) and frequency. Two-year measurements of both the rainfall rate and rain attenuation over two experimental links operating at 26 and 38 GHz at a 0.3 km path length are used to validate and enhance the model. The measurements and experiments are conducted in Malaysia. The result indicated that the shorter the link, the higher the expected R_{eff}. One aspect that may partially justify this significant increase in R_{eff} is the fact that the ITU-R P.838-3 model does not consider the impact of the raindrop size distribution (DSD)for tropical climates when predicting rain attenuation at a short-range mm-wave link. The proposed model estimations are compared with experimental attenuation results reported at 73.5GHz and 83.5GHz over a 0.3 km path length. Several experimental results reported from different regions around the globe are used to validate the proposed model. The outcomes are in good agreement. The findings emphasize the importance of developing region-specific models that consider local meteorological variations, potentially offering significant improvements to the reliability and design of mm-wave communication systems and realizing the future goal of 6G wireless mobile fronthaul. © 2025

Author keywords

Distance factor; Effective rain rate; Millimetre-wave; Predicted rain fade; Short-length; Terrestrial Links

Indexed keywords

Engineering controlled terms

Rain; Rain gages; Time difference of arrival

Engineering uncontrolled terms

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