Modeling the Effects of Rain on Ka Band Systems

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Abstract

Rain can cause significant attenuation on earth-space paths at Ka band. System engineers need to take the effects of rain into account in estimating the availability of any Ka band system that they design. Propagation models are required to estimate availability because long term, direct measurements are not available. Two kinds of propagation models are in general use, physical models that provide estimates on the basis of climatological data and propagation physics, and regression models that provide curve fits to the statistical path attenuation and rain rate observation data stored in data banks. Both types of models will be discussed.

The NASA ACTS Propagation Experiment was designed to provide long-term measurements on Ka band earth-space paths for model development and validation. Five years of continuous path attenuation observations were collected for seven locations in the United States and Canada. These data provide statistical estimates of the expected probability of exceeding specified attenuation levels and the year-to-year variation in the probability values for the same attenuation levels. Data were collected at two frequencies, 20.2 and 27.5 GHz, from sites ranging from 28 to 64 deg. north latitude employing path elevation angles ranging from 8 to 52 degrees. The observations were from a larger range of rain climates than any previous set of measurements in North America.

Comparisons were made between the annual attenuation statistics predicted by 1) the revised Crane Two-Component physical model and 2) the recently adopted ITU-R Study Group 3 regression model. Before any comparison could be made, corrections were applied to the attenuation observations to remove the additional attenuation caused by water on the antenna reflector surface and on the antenna feed window. After correction, for the 70 path years of data from the ACTS experiment, the physical model predicted the observation statistics within the expected uncertainty due to year-to-year variations while the regression model showed significant differences. If the 30 path years of earlier observations from the United States stored in the data bank were used for testing, the regression model performance was superior to that of the physical model.