Modeling of Cloud Attenuation on Earth - Space Path in Ota Southwest Nigeria

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Abstract:
A new cloud attenuation model on earth-space path has been develop for a tropical station (6.7°N, 3.23°E) based on cloud cover, radiometric measurement and climatological data at the Covenant University in Ota. The collection of station data by a 7GHz spectrum analyzer for the total attenuation at elevation angle of 59.9° to Astra 2 satellites located at longitude 28.2°E. Automatic weather station parameters and daily visual clouds observation; as well as the acquisition of station radiosonde data were carried out. The station spectrum analyzer data between 2014 and 2017 were analyzed to obtain cloud attenuation contributions from the total attenuation measurement. The measured Cloud attenuation was compared with eight existing cloud attenuation models. Cloud attenuation at 12.245 GHz is 3.40 dB compare to 0.81 dB cloud attenuation predicted by ITU-RP 840 model, next is the Liebe's model, followed by Slobin model. A new developmental model was derived for the tropical station. The new cloud attenuation model was developed using the station radiosonde data from 1953-2011 for the computations of each cloud layer's liquid water content and specific attenuation coefficient. The cumulative distribution curves obtained was compared with each simulation distribution and the closest match to the station measured cumulative distribution is considered in the new cloud attenuation model for the station. The new model predicted 4.0 dB margins for clouds attenuation at 0.01% unavailability for the station. The study reveal cloud attenuation was under estimate by the eight existing cloud attenuation model for the tropical station.

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I. Introduction

Electromagnetic signals transmission through the earth - space paths will have to pass through the Earth's cloudy atmospheric layers. Cloud attenuation is due to absorption of propagating signals' energy by clouds constituent small water droplets when an electromagnetic signal passes through them. Previous studies show that the cloud liquid water content in a cloud body is directly proportional to cloud attenuation amount a traversing electromagnetic signal will experience in passing through it; and satellite signal is completely lost whenever receiving signal level drop below the noise floor [1]. Each atmospheric layer condition changes with time due to direct and indirect solar radiations incidence effects, for example heat effect on its constituent matter such as gas molecules, ions, water vapour and clouds causes their transformations into varying forms [2]. Generally, following previous observation the dynamics of horizontal and vertical structure of rain and cloud are directly related to local geology and climate [3]. Specifically, the tropospheric layer of the atmosphere largely accommodates the clouds, and it extends up to about 8 km over the poles and to about 18 km over the equator. On any given day about half of the Earth is covered by clouds, which reflects more sunlight than land and water [2], [4], [5]. There are ten cloud types [6], of which eight can be seen in non-rainy weather, namely Cumulus (C), Stratus (St), Stratocumulus (Sc), Altocumulus (Ac), Altostratus (As), Cirrus (Ci), Cirrocumulus (Cc), Cirrostratus (Cs) and the remaining two clouds are associated with rain, namely Cumulonimbus (Cb) and Nimbostratus (Ns). Satellite signals transmission through cloudy weather require extra power margin to burn through propagation paths in the atmosphere and the effects of the troposphere on radiowaves therefore becomes more acute for systems operating in the bands above 10 GHz, where radiowave links can be adversely affected by atmospheric hydrometeors such as water vapour, rain, clouds and fog [7], [8].