Comparing One-Minute Rain Rate Distributions from TRMM Satellite Data and Rec. ITU-R P.837-7 in the Tropics

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***Abstract*— Rain attenuation is the dominant impairment on terrestrial and microwave links, with attenuation growing significantly as the frequencies increase above 10 GHz to 100 GHz. The ITU-R rain fade models for terrestrial and Earth-space links require the one-minute rain rate exceeded for 0.01% of an average year, R0.01%, as a fundamental parameter. For locations without reliable long-term rainfall data, Rec ITU-R P.837-7 provides a method for predicting one-minute rain rate distributions. This paper seeks to compare the one-minute rain rate distributions provided by Rec ITU-R P.837-7 over the tropics with one-minute rain rate distributions derived from TRMM satellite data, and DBSG3 the propagation database of ITU-R Study Group 3.**

Keywords— ***rain, rain fade, microwave, propagation, satellite data, point one-minute***

I. INTRODUCTION

The fundamental input parameter to the International Telecommunications Union - Radio Section (ITU-R) models of rain fade on terrestrial and Earth-space links, Rec. ITU-R P.530-16 [1] and Rec. ITU-R P.618-12 [2] respectively, is the one-minute rain rate exceeded for 0.01% of an average year, R0.01%. Locations around the world that do not have a reliable, long-term record of high-resolution rainfall data rely on the distributions provided by the Rec ITU-R P.837-7 [3]. The Recommendation uses inputs derived from a global rain gauge network and reanalysis data i.e. the Global Precipitation Climatology Centre (GPCC) gridded rain gauge dataset and European Centre for Medium-Range Weather Forecasts (ECMWF) ERA Interim database, over land and water respectively. This paper develops estimates of average annual point one-minute rain rate distributions for the tropics using TRMM 2A25 data from Tropical Rain Measuring Mission TRMM precipitation radar (PR) data. The 5 km PR pixels are smaller than the typical convective rain cell, which is 10 km in diameter. GPCC data with the finest resolution of 0.25° is much larger than a convective cell. Reference [4] has shown using UK Nimrod radar data with a 1 km resolution, that instantaneous rain rates averaged over 1 km squares provide unbiased estimates of point one-minute rain rates exceeded 0.01% of the time. More information on TRMM 2A25, Nimrod and DBSG3 can be obtained from "in press"[5].

II. METHODOLOGY

TRMM 2A25 data from 9 years, 2004 to 2012, were downloaded and analyzed. Each 5 km rain rate measurement was allocated to a single 1° by 1° square by its latitude and longitude. Histograms of measurements were calculated for each 1° square and these were transformed into exceedance distributions. The TRMM 5 km instantaneous rain rates were transformed into distributions of point one-minute rain rates. This was accomplished using the quadratic transformation between 5 km and 1 km rates calculated from Nimrod data. The relationship between the TRMM 5 km rain rate R_{5km}, and 1 km rain rate R_{1km} is given by the expression:

$$R_{1km} = \alpha R_{5km}^2 + \beta R_{5km} \quad (1)$$

where α = 0.0126 and β = 1.0619 "in press"[5].
Locations with DBSG3 data were used to compare the TRMM and Rec. ITU-R P.838-7 R0.01%, values.

III. COMPARISON OF POINT ONE-MINUTE RAIN RATES

The estimates of TRMM and Rec. ITU-R P.837-7 were compared to DBSG3 data for the tropical locations of interest. This was achieved using the method provided by Rec. ITU-R P.311, which uses the Goodness of Fit (GoF) metric to measure the distance between pairs of fade exceedance distributions. The GoF for the 0.01% exceeded rain rate for TRMM and ITU-R. P.837-7 compared to DBSG3 data was 0.145 and 0.05 respectively. The estimates from six sites were observed to be outliers. The sites, Ayura to San Cristobal, are close together in Columbia, within the Ayura valley and in the wind shadow of the Central Range Mountains. It is likely that these results are not representative of the region; hence, the GoF metric was calculated excluding them. In this case, the GoF for TRMM was seen to improve to a value of 0.0542 and that for Rec. ITU-R P.837-7 was 0.0582.

Plots of point one-minute rain rates for TRMM and Rec. ITU-R P.837-7 are shown in Fig. 1 and Fig. 2 respectively. It can be observed that there is great similarity in the two plots where rain rates between 80 – 90mm/h are recorded along the

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coastal areas of West Africa, in the Northern regions of South America and over the South Atlantic, Pacific and Indian oceans. The TRMM plot however, has captured rain rates of the same level of 80 – 90mm/h in regions of West and Central Africa, The Island of Madagascar, Southern regions of South America, and some regions of North America, which the Rec ITU-R P.837-7 does not. These and other differences are shown in Fig. 3, which is a plot of the difference in 0.01% rain rates exceeded for TRMM and Rec ITU-R P.837-7.

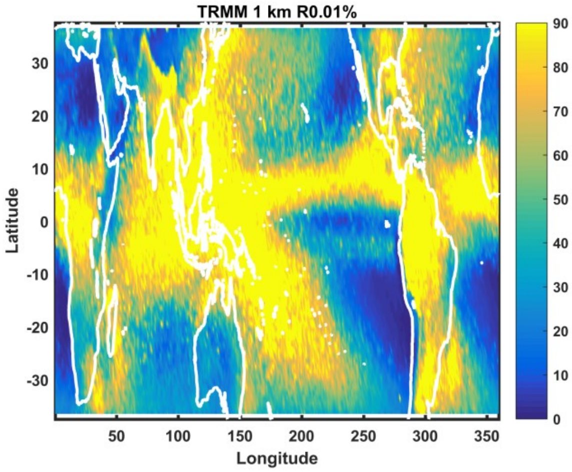

Fig.1 0.01% exceeded rain rates derived from distributions of TRMM 5 km rain rates transformed using (1).

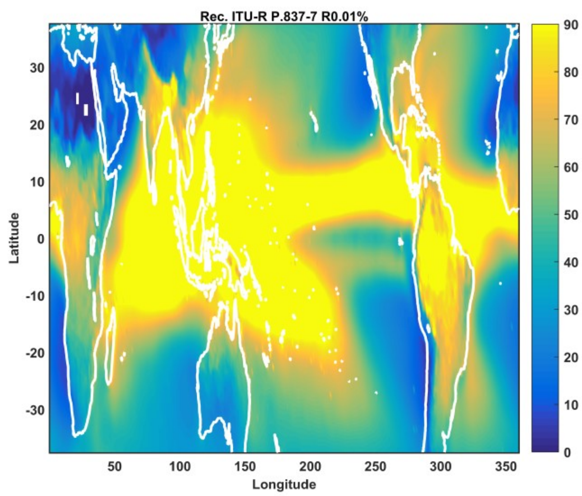

Fig.2. 0.01% exceeded rain rates derived from Rec. ITU-R P.837-7 prediction

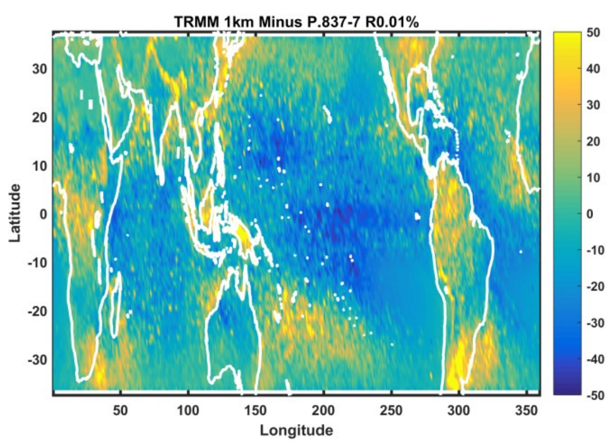

Fig.3. Difference between 0.01% exceeded rain rates derived from transformed TRMM 5 km rain rates and rec. ITU-R P.837-7 prediction.

III. CONCLUSIONS

The current Rec. ITU-R P.837-7 is based on transformations from climate parameters measured over scales larger than convective rain cells, and is seen to perform poorly in the tropics. Data from the TRMM satellite mission yields a large amount of data derived from integration regions smaller than convective cells that are fundamentally important for radio system design and regulation. A transformation from 5 km rain rate distributions to 1 km distributions has been derived from UK data and applied in the tropics. The validity of this has been tested against the DBSG3 database of rain rate distributions. Furthermore, the TRMM method relies on more recent data than methods based on GPCC, ERA Interim and other reanalysis data, and so is more likely to match the present day climate.

ACKNOWLEDGMENT

We made use of TRMM 2A25 data downloaded from https://search.earthdata.nasa.gov/?q=TRMM+2A25&ok=TRMM+2A25. Use was also made of Nimrod composite rain maps produced by the UK Meteorological Office and supplied by the British Atmospheric Data Centre.

The DBSG3 database is maintained by ITU-R Study Group 3 and is accessible to SG3 members through the TIES system: https://www.itu.int/TIES/.).

REFERENCES

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