An investigation into the effect of the integration time on the rainrate distribution*

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Abstract

An investigation into the effect of the integration time $T$ on the rain rate distribution is presented using a rainfall rate data bank from an extensive network of raingauges around the Greek area (ccir-zones K and L). Comparison with results from other countries reveals again the significant climatic dependence of the conversion factors between the various T-min rainrate distributions.

Key words: Rainfall rate, Statistical study, Rain gauge, Climatology.

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I. INTRODUCTION

It is widely accepted that attenuation of radio waves by atmospheric precipitation (mainly rain) represents a serious obstacle to microwave transmission at frequencies in excess of about 10 GHz. One of the serious problems in microwave communication planning is the prediction of the attenuation due to rain in a radio link by using reliable long-term rain rate statistics. It should be noted here that the prediction of the rain attenuation distribution usually requires quasi-instantaneous or at most 1-min point rainrate distributions. Recently, ccri has adopted the use of 1-min integration time as a convenient reference sampling time [1]. On the other hand, incomplete or short term rainfall data of such small integration time is usually available and this lack of information has forced radio engineers to use sources of rain records such as those available in the meteorological services to estimate the rainrate distribution. Due to the limited resolution of the chart recordings the statis-

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tical distributions of rainrate derived by these accumulation rainfall amounts are referred to integration times \( T \) of not less than 5-min and this makes inevitable the development of conversion factors between the various \( T \)-min rainrate distributions. From the above, it is clear that the effect of the integration time on the rainrate distribution is of interest.

In the past years several attempts were made to relate instantaneous rainfall distributions, with those for large integration times. More particularly, Harden et al [2] tried to find the appropriate reduction factors by using rainfall distributions measured at Slough, United Kingdom. Further, Fedi [3], as a part of the EUROCOP-COST 25/4 project, examined the same effect for several European locations such as Rome, Italy and Darmstadt, Germany. Watson et al [4] also examined the 5- and 10-min rainfall conversion factors to 1-min for some other locations in Europe. Danosso et al [5] studied the characteristics of rainfall at Turin and Bari in Italy and presented power-law curves relating the various distributions with one another. A similar power-law fit was proposed by Flavin [6] and Ajayi and Ofochie [7] by examining the cumulative distributions for locations in Europe, North America, Australia and Nigeria. Most recently, Segal [8] has published conversion factors for Canada by analyzing a large data bank stressing the climatic zone dependence. Finally, Burgueño et al [9] investigated the effect of the integration time on the rainrate distribution by using a rainfall data bank of 49 years recorded at Barcelona, Spain. The dependence of the effect of the integration time upon the rainrate distribution on the climatic zone has also been observed there and the need for mapping the conversion factors from one locality to another has been made clear.

Following the above considerations, the same effect is examined here by using available rainfall rate data of various integration times for nine representative Greek localities belonging to two climatic zones (K and L). In this paper, we present the appropriate conversion factors between time-averaged distributions, and we compare them with those of other climatic zones. Some useful conclusions are deduced.

### II. DESCRIPTION OF THE DATA BANK

The nine Greek localities where Special Meteorological Stations have been installed are the following: Mikra (Salonica), Kefalonia, Kalamata, Milos, Hios, Aliartos, Kerkira, Heraklion, Yma (Athens). For each of the above localities the appropriate experimental results were taken from archives of rainfall rate data given by the Direction of Research of the Hellenic Telecommunication Organization S.A. (OTE) and they constitute part of the final report of the research project COST 25/4. The above project in cooperation with other European countries such as Italy, France, England, Germany, Sweden, Portugal etc., aimed at the collection and the appropriate elaboration of data concerning propagation of microwaves through rain medium. It should be noted here that Fedi [3] has already presented ratios of 5- and 10-min rainfall intensities to the equally probable 1-min rates for two European locations (Rome, Italy and Darmstadt, Germany) but without further analysis. The data for the Greek airspace is referred to the period 1974-75 and gives the appropriate experimental basis for the development of the present study.

The Special Meteorological Stations were equipped with two types of raingauges, rapid response (rrr) and standard raingauges (ssr). A description of the rapid response raingage is given elsewhere [9], whereas the standard raingauges are the usual instruments employed by the meteorological services. Using the first type of raingauges (rrr), rainfall rate statistics were obtained referring to integration times 15 sec. This means that the rainrates are considered to be quasi-instantaneous. Further, the rainrate in a \( T \)-min interval was obtained by integrating the rainrate records within successive intervals of clock \( T \) min and dividing the result by \( T \). In this way, 1 min, 5 min, 10 min, 30 and 60 min rainrate distributions have been derived. The above procedure, of integrating the rainrate records to derive a \( T \)-min rainrate \( R_T \) is quite close to the value measured by a gauge which had an integration time of \( T \) min [9].

In our case, we have also verified the above argument by comparing the so obtained \( R_T \) distributions (for \( T = 5, 10, 30, 60 \) min) with the corresponding ones taken from the standard raingauge (ssr) measurements.

Finally, as perhaps expected, the \( P(T) \) distributions are very close to the quasi-instantaneous distributions (15 s) for each locality over the whole range of rainrates. This has also been noticed by Burgueño et al [9] for the Jardi recordings from Barcelona and this could be due to the inevitable limited resolution of the chart recordings.

### III. ANALYSIS AND NUMERICAL RESULTS

The conversion factors translating the quasi-instantaneous to equivalent \( \tau \)-min rainfall distributions may be carried out in different ways. In one, the conversion is expressed in terms of the ratio of equiprobable rainfall rates:

\[
\rho_T(P) = \frac{R_\tau(P)}{R_T(P)}
\]

where \( R_\tau \) and \( R_T \) are the rainfall rates exceeded with equal probability, \( P \), for the two integration times. The value of 1 min as reference has been selected for convenience and to help in the comparison with other results. An alternative method of expressing the