RECOMMENDATION ITU-R P.837-5

Characteristics of precipitation for propagation modelling

(Question ITU-R 201/3)

(1992-1994-1999-2001-2003-2007)

Scope

Recommendation ITU-R P.837-4 contains maps of meteorological parameters that have been obtained using the European Centre for Medium-Range Weather Forecast (ECMWF) ERA-15 re-analysis database. New maps have been generated using the ECMWF ERA-40 re-analysis database, which is a new product generated by ECMWF using improved assimilation and forecast procedures and covering a longer time period with improved spatial resolution. In addition, the regression coefficients used in the prediction of rainfall rate have been optimized.

Rainfall rate statistics with a 1-min integration time are required for the prediction of rain attenuation in terrestrial and satellite links. Data of long-term measurements of rainfall rate may be available from local sources, but only with higher integration times. This Recommendation provides a method for the conversion of rainfall rate statistics with a higher integration time to rainfall rate statistics with a 1-min integration time.

The ITU Radiocommunication Assembly,

considering

a) that information on the statistics of precipitation intensity is needed for the prediction of attenuation and scattering caused by precipitation;

b) that the information is needed for all locations on the globe and a wide range of probabilities;

c) that rainfall rate statistics with a 1-min integration time are required for the prediction of rain attenuation and scattering in terrestrial and satellite links;

d) that long-term measurements of rainfall rate may be available from local sources with a 1-min integration time and also, with integration times of longer than 1-min,

recommends

1 that the model in Annex 1 should be used to obtain the rainfall rate, R_p, exceeded for any given percentage of the average year, p, and for any location (with an integration time of 1 min). This model is to be applied to the data supplied in the digital files ESARAIN_xxx_v5.TXT (the data files may be obtained from that part of the ITU-R website dealing with Radiocommunication Study Group 3);

2 that, for easy reference, Figs. 1 to 6 in Annex 2 should be used to select the rainfall rate exceeded for 0.01% of the average year. These figures were also derived from the model and data described in Annex 1;

3 that local long-term measurements of rainfall rate with a 1-min integration time should be used if available;

4 that long-term measurements of rainfall rate with longer integration times should be used if available and the model in Annex 3 be used to convert to rainfall rate with a 1-min integration time.

Annex 1

Model to derive the rainfall rate exceeded for a given probability of the average year and a given location

The data files ESARAIN_PR6_v5.TXT, ESARAIN_MT_v5.TXT and ESARAIN_BETA_v5.TXT contain respectively the numerical values for the variables P_{r6}, M_t and β while data files ESARAINLAT_v5.TXT and ESARAINLON_v5.TXT contain the latitude and longitude of each of the data entries in all other files. These data files were derived from 40 years of data from the European Centre of Medium-range Weather Forecast (ECMWF).

Step 1: Extract the variables P_{r6}, M_t and β for the four points closest in latitude (Lat) and longitude (Lon) to the geographical coordinates of the desired location. The latitude grid is from +90° N to –90° S in 1.125° steps; the longitude grid is from 0° to 360° in 1.125° steps.

Step 2: From the values of P_{r6}, M_t and β at the four grid points, obtain the values $P_{r6}(Lat,Lon)$, $M_T(Lat,Lon)$ and $\beta(Lat,Lon)$ at the desired location by performing a bi-linear interpolation, as described in Recommendation ITU-R P.1144.

Step 3: Convert M_T and β to M_c and M_s as follows:

$$M_c = \beta \, M_T$$

$$M_s = (1-\beta) \, M_T$$

Step 4: Derive the percentage probability of rain in an average year, P_0, from:

$$P_0(Lat,Lon) = P_{r6}(Lat,Lon)\left(1 - \mathrm{e}^{-0.0079\,(M_s(Lat,Lon)/P_{r6}(Lat,Lon))}\right) \qquad (1)$$

If P_{r6} is equal to zero, the percentage probability of rain in an average year and the rainfall rate exceeded for any percentage of an average year are equal to zero. In this case, the following steps are unnecessary.

Step 5: Derive the rainfall rate, R_p, exceeded for p% of the average year, where $p \leq P_0$, from:

$$R_p(Lat,Lon) = \frac{-B + \sqrt{B^2 - 4AC}}{2A} \quad \text{mm/h} \qquad (2)$$

where:

$$A = a\,b \qquad (2a)$$

$$B = a + c\,\ln(p/P_0(Lat,Lon)) \qquad (2b)$$

$$C = \ln(p/P_0(Lat,Lon)) \qquad (2c)$$

and

$$a = 1.09 \qquad (2d)$$

$$b = \frac{(M_c(Lat,Lon) + M_s(Lat,Lon))}{21797 P_0} \qquad (2e)$$

$$c = 26.02b \qquad (2f)$$

NOTE 1 – An implementation of this model and the associated data in MATLAB is also available from the ITU-R website dealing with Radiocommunication Study Group 3.

Annex 2

FIGURE 1

Rain rate (mm/h) exceeded for 0.01% of the average year

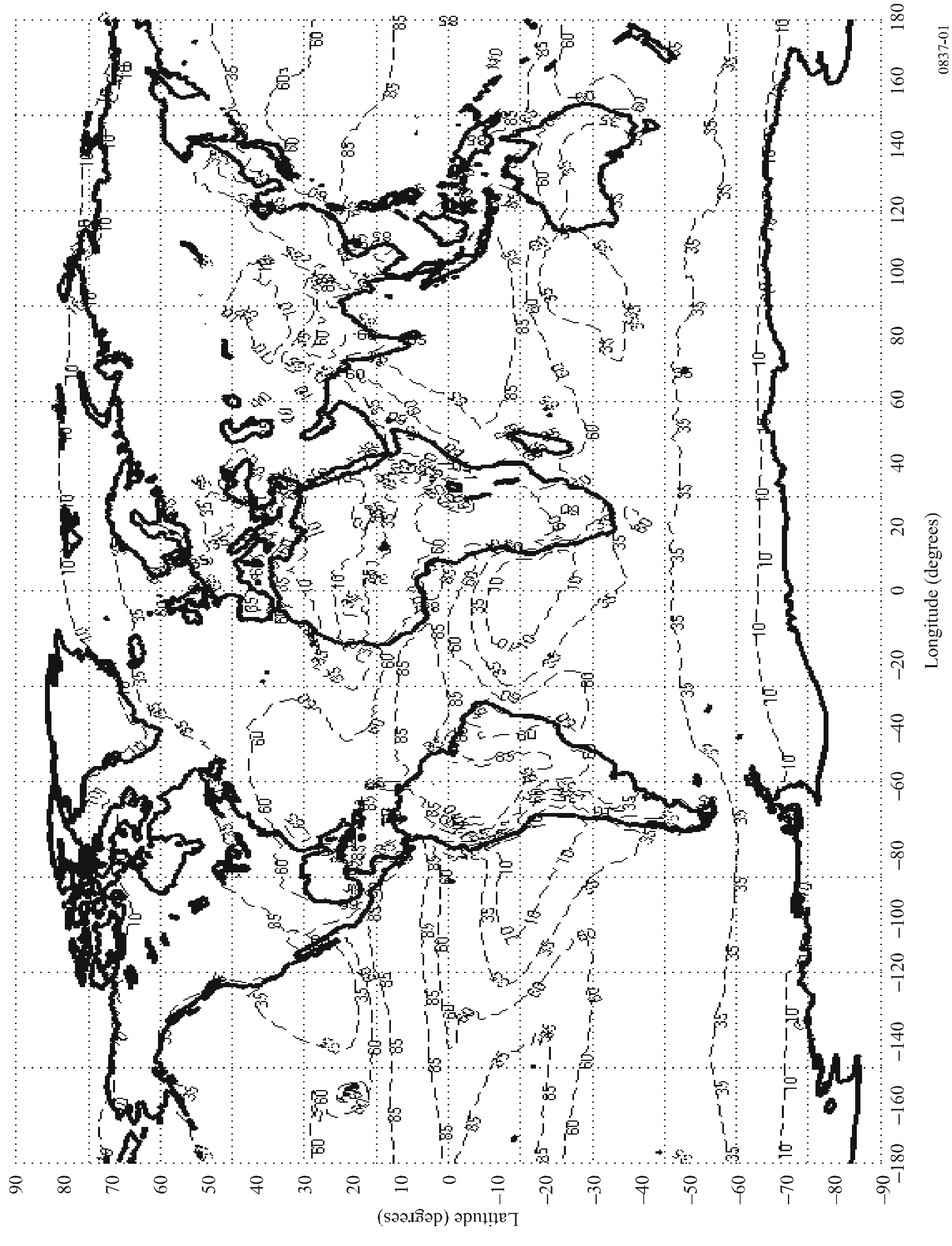

FIGURE 2

Rain rate (mm/k) exceeded for 0.01% of the average year

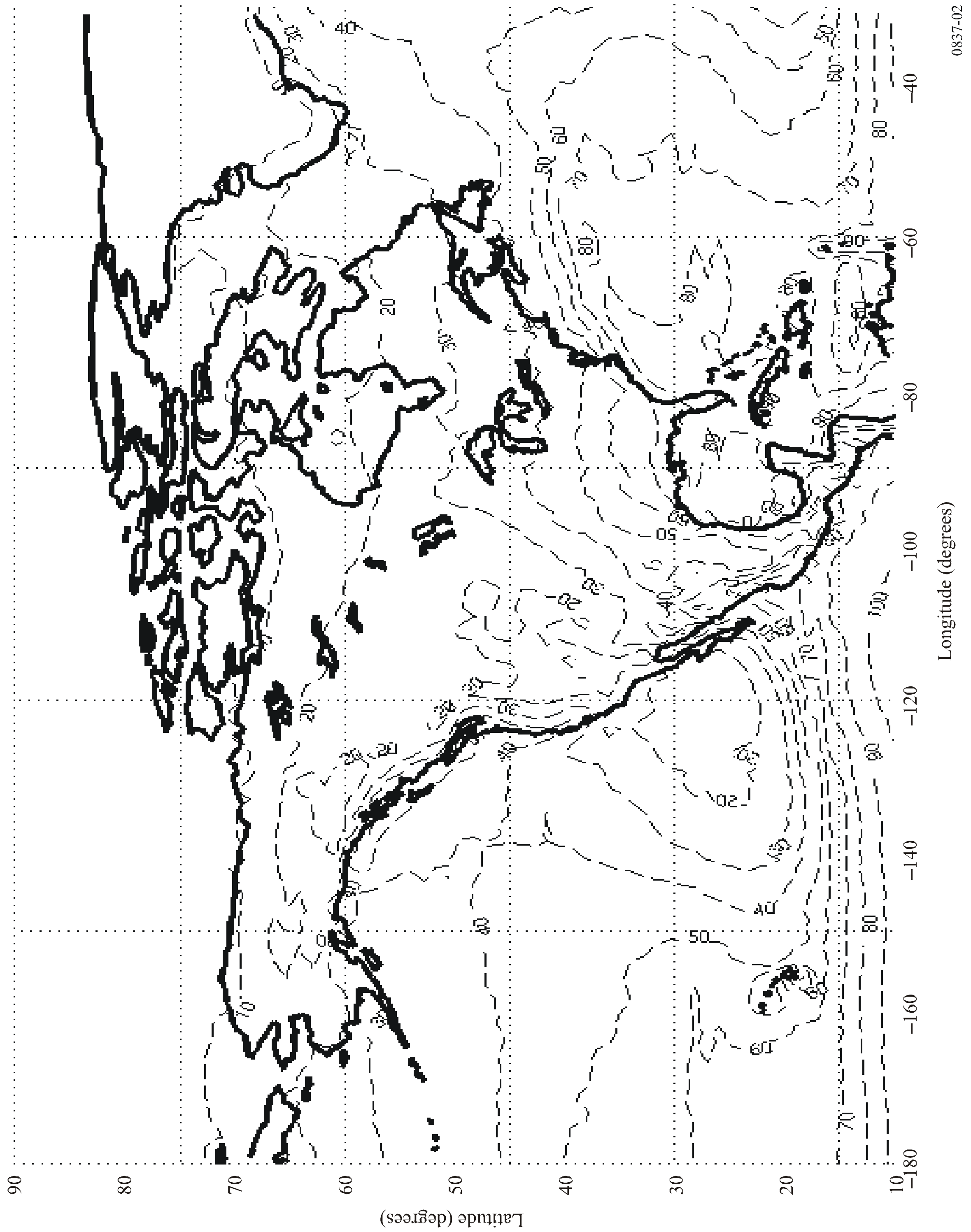

FIGURE 3

Rain rate (mm/h) exceeded for 0.01% of the average year

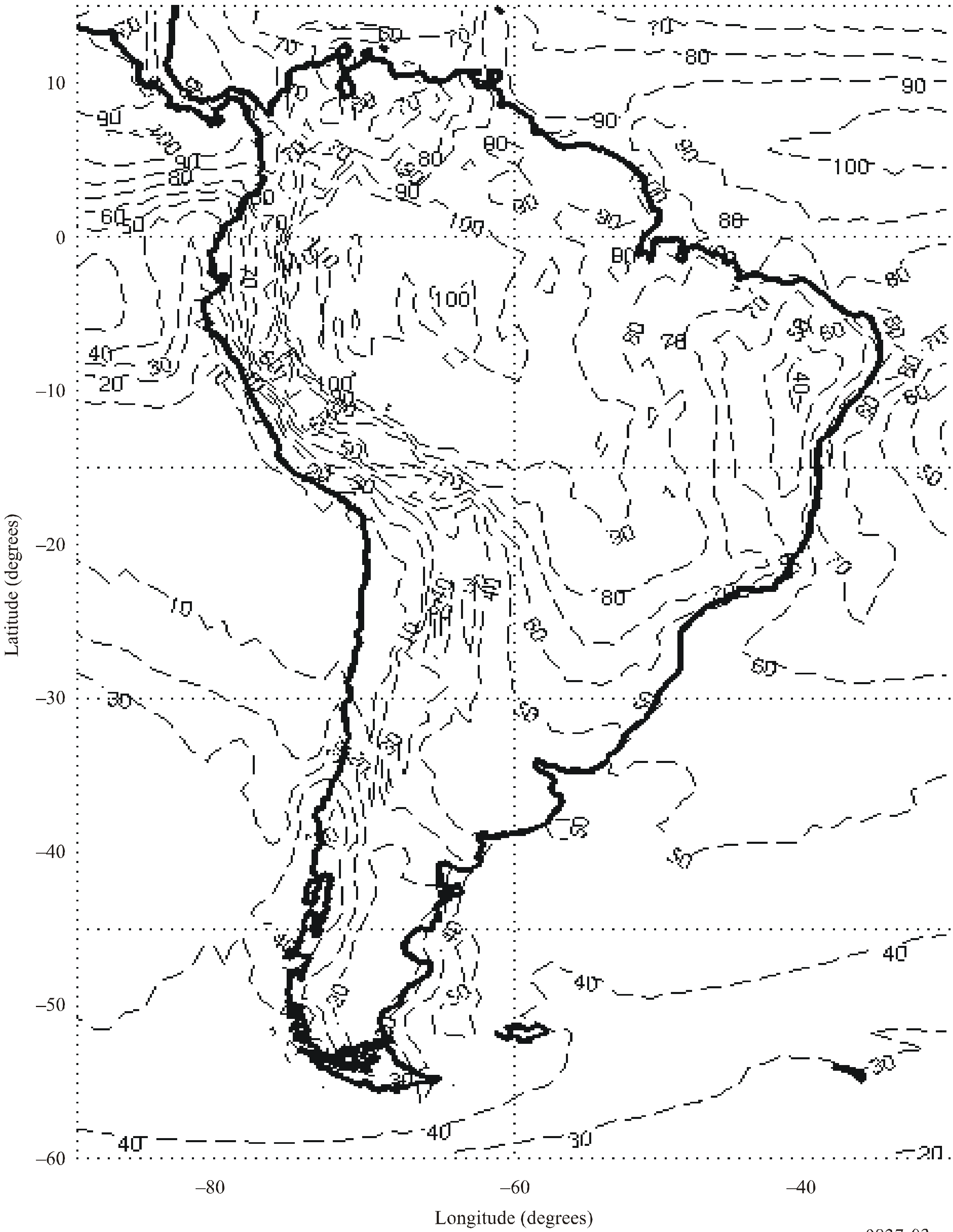

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FIGURE 4

Rain rate (mm/h) exceeded for 0.01% of the average year

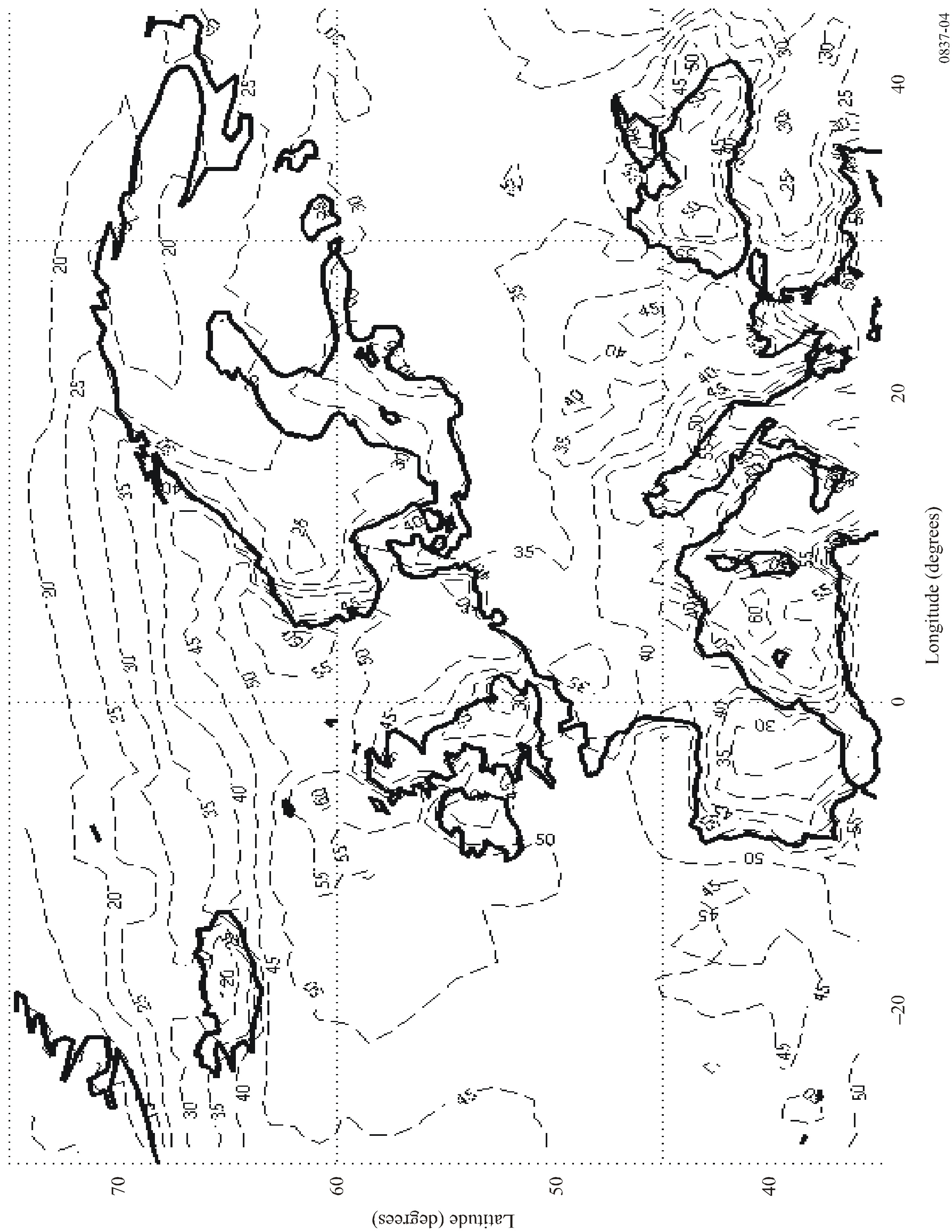


FIGURE 5

Rain rate (mm/h) exceeded for 0.01% of the average year

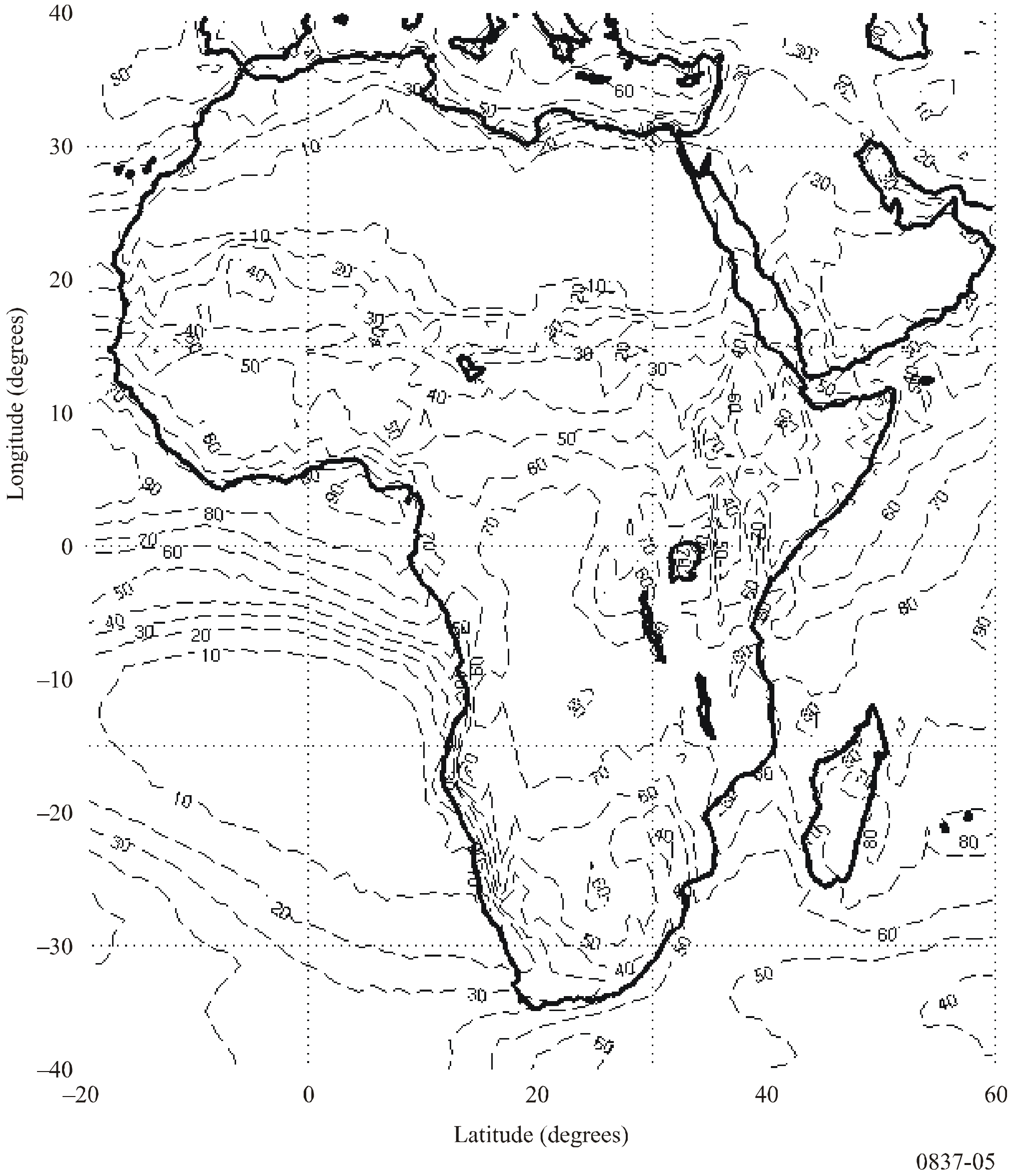


FIGURE 6

Rain rate (mm/h) exceeded for 0.01% of the average year

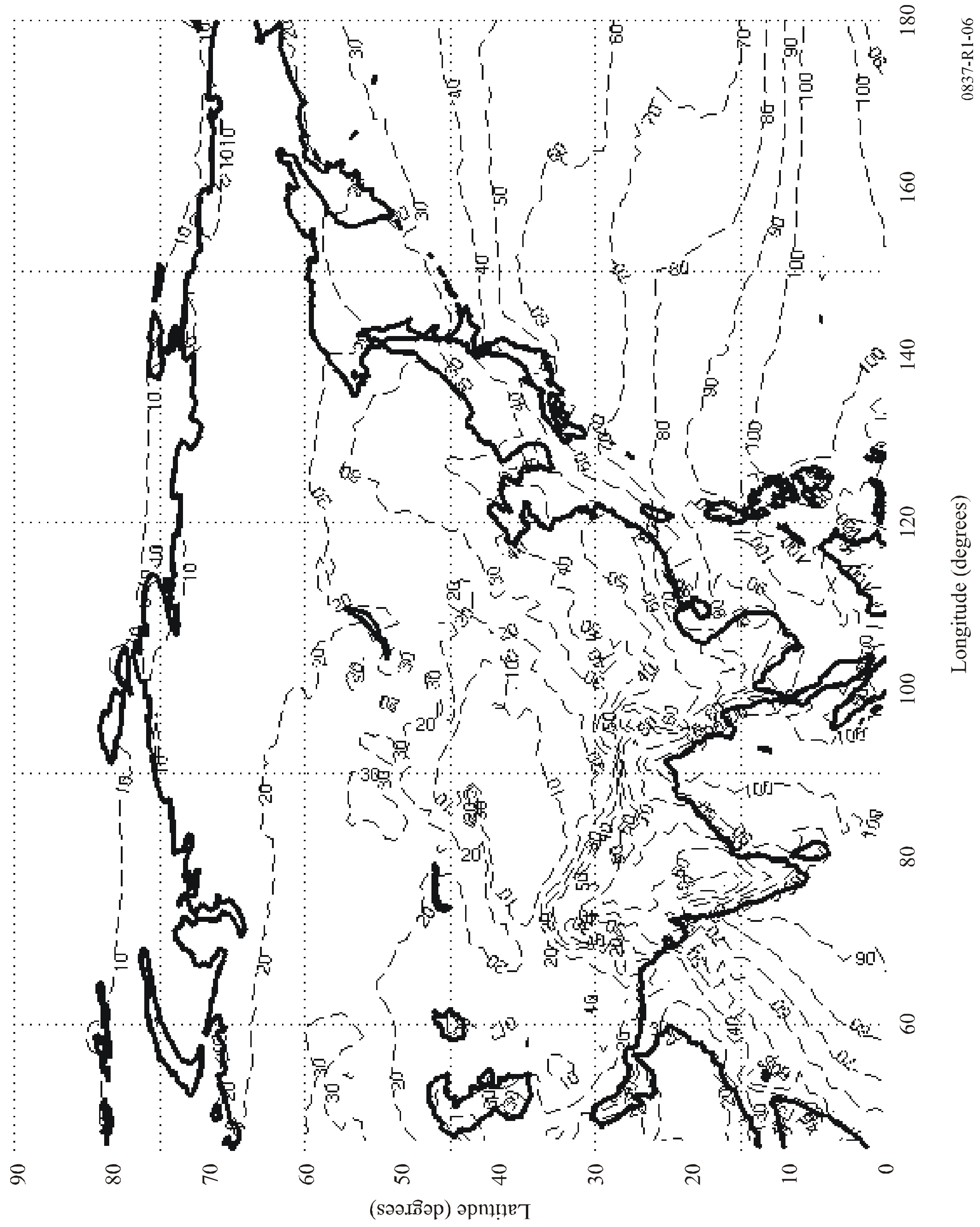


FIGURE 7

Rain rate (mm/h) exceeded for 0.01% of the average year

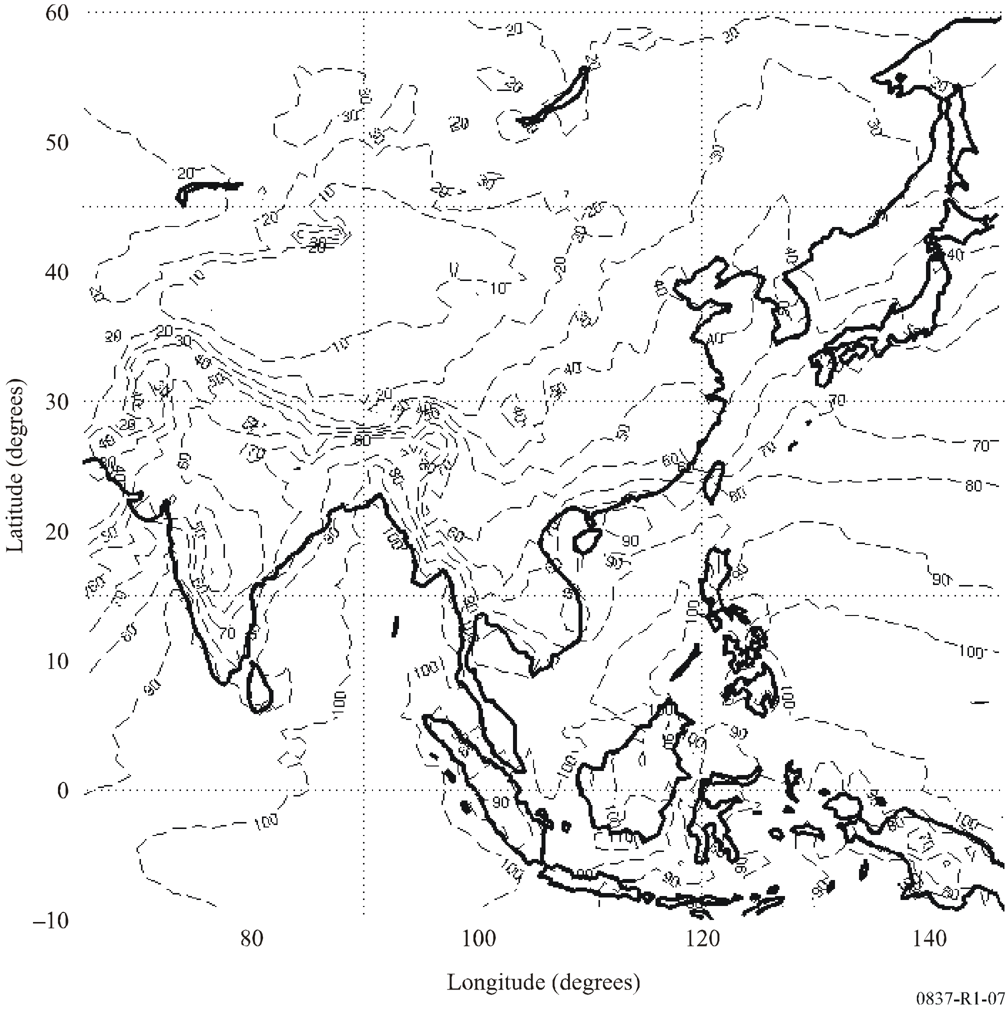
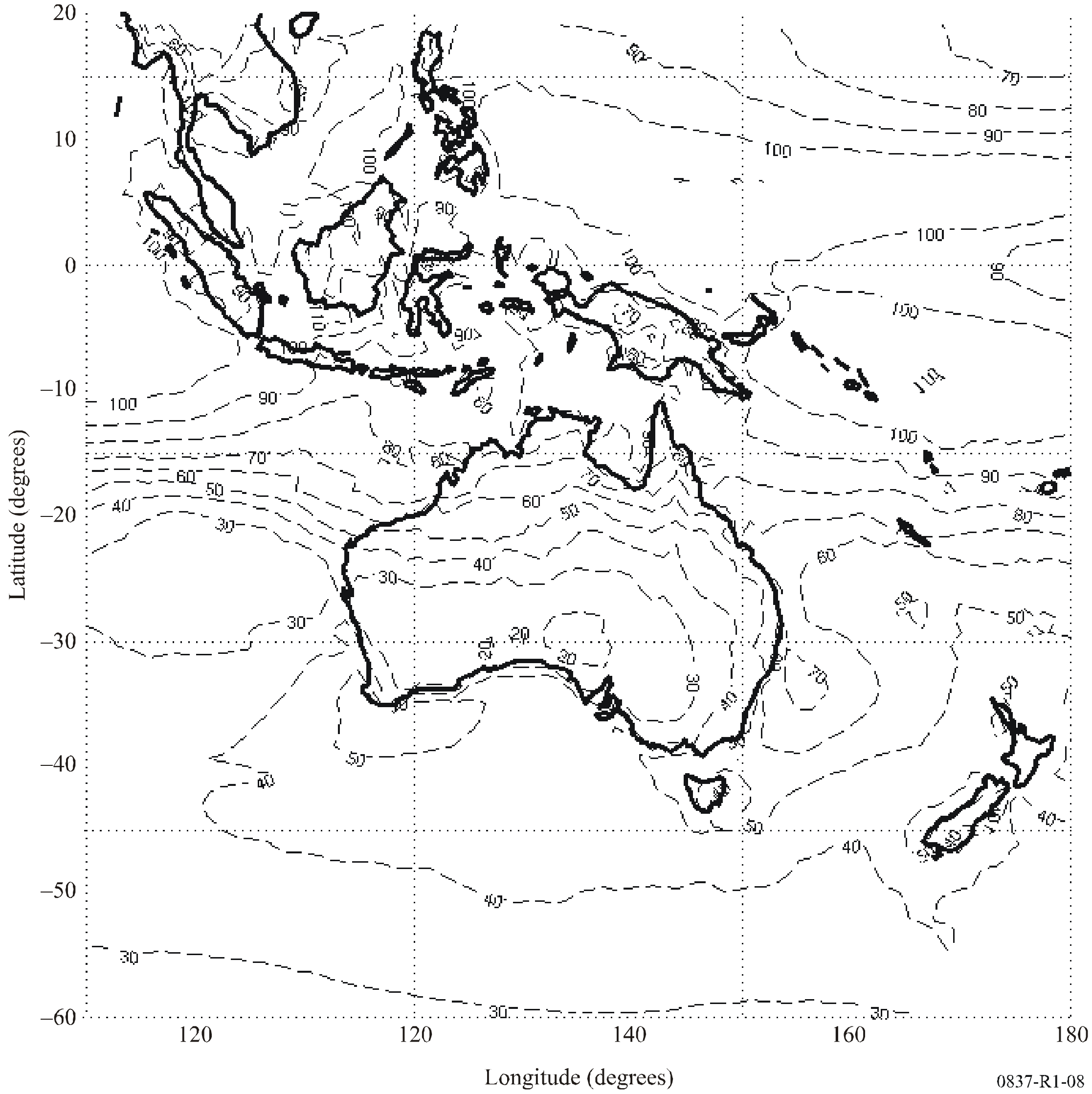


FIGURE 8

Rain rate (mm/h) exceeded for 0.01% of the average year



Annex 3

1 The cumulative distribution of rainfall rate for a 1-min integration time can be obtained by converting cumulative distributions with higher integration times using the following relationship:

$$R_1(p) = a[R_\tau(p)]^b \qquad \text{mm/hr} \qquad (3)$$

where $R_1(p)$ and $R_\tau(p)$ are the rainfall rates with 1-min and τ-min integration times exceeded with equal probability, p%, and a and b are regression coefficients.

2 Values of coefficients a and b, for integration times of 5 min, 10 min, 20 min and 30 min, are given in Table 1 (see Note 1).

TABLE 1

a and b values for various integration times

τ	a	b
5 min	0.986	1.038
10 min	0.919	1.088
20 min	0.680	1.189
30 min	0.564	1.288

NOTE 1 – These values have been obtained from long-term measurements of point rainfall rate at 14 sites in Korea, China and Brazil. In the range from 0.01% to 0.1% of time, the average values of the absolute differences between the measured and converted 1-min rainfall rates were found to be 1.14 mm/h for the conversion from 5-min to 1-min integration times, 1.90 mm/h for the conversion from 10-min to 1-min integration times, 3.69 mm/h for the conversion from 20-min to 1-min integration times and 5.72 mm/h for the conversion from 30-min to 1-min integration times. For other regions different coefficients may be required.

NOTE 2 – The measurement period required to predict the cumulative probability of rainfall depends on the characteristics of the local climatology. Studies of long-term data have shown that a period of between 3 and 7 years is usually appropriate.