

Recommendation ITU-R P.837-8

(09/2025)

P Series: Radio-wave propagation

Characteristics of precipitation for propagation modelling

Foreword

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Series of ITU-R Recommendations

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Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radio-wave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R P.837-8

Characteristics of precipitation for propagation modelling

(Question ITU-R 201-7/3)

(1992-1994-1999-2001-2003-2007-2012-2017-2025)

Scope

Rainfall rate statistics with a 1-min integration time are required for the prediction of rain attenuation in terrestrial links (e.g. Recommendation ITU-R P.530) and Earth-space links (e.g. Recommendation ITU-R P.618).

When reliable long-term local rainfall rate data is not available, Annex 1 of this Recommendation provides a rainfall rate prediction method for the prediction of annual and monthly rainfall rate statistics with a 1-min integration time. This prediction method is based on: a) total monthly rainfall data generated from the GPCC Climatology (V 2015) database over land and from the European Centre for Medium-Range Weather Forecast (ECMWF) ERA Interim re-analysis database over water, and b) monthly mean surface temperature data in Recommendation ITU-R P.1510.

When reliable long-term local rainfall rate data is available with integration times greater than 1-min, Annex 2 of this Recommendation provides a method for converting rainfall rate statistics with integration times that exceed 1-min to rainfall rate statistics with a 1-min integration time.

Keywords

Rainfall rate, annual statistics, monthly statistics, conversion method, GPCC, ERA Interim

Abbreviations/Glossary

ECMWF European Centre for Medium-Range Weather Forecast

ERA ECMWF re-analysis database

GPCC Global Precipitation Climatology Centre

Related ITU-R Recommendations

Recommendation ITU-R P.1510 – Mean surface temperature

NOTE – The latest edition of the Recommendation in force should be used.

The ITU Radiocommunication Assembly,

considering

- a)* that information on the yearly and monthly statistics of precipitation parameters are needed for the prediction of attenuation and scattering caused by precipitation;
- b)* that the information is needed for all locations on the surface of the Earth 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 that exceed 1-minute;
- e)* that using a model to convert local rainfall rate measurements with integration times up to 1 hour into an integration time of 1-minute may provide higher accuracy than Annex 1 to this Recommendation,

recommends

- 1 that local long-term measurements of annual and monthly rainfall rate with a 1-minute integration time should be used if available;
- 2 that local measurements, if used, are collected over a sufficiently long period of time (typically longer than 10 years), to ensure statistical stability;
- 3 that long-term measurements of annual rainfall rate with integration times that exceed 1 minute should be used if available, and the conversion method in Annex 2 should be used to convert these measurements to annual rainfall rate with a 1-minute integration time;
- 4 that, in the absence of reliable local annual rainfall rate data, the step-by-step prediction method in Annex 1 should be used to obtain the rainfall rate, R_p , exceeded for the desired annual probability of exceedance, p , for any location on the surface of the Earth, and for an integration time of 1 minute;
- 5 that, in the absence of reliable local monthly rainfall rate data, the step-by-step prediction method in Annex 1 should be used to obtain the monthly rainfall rate, $R_{p_{ii}}$, exceeded for the desired probability of exceedance, p , in month ii (ranging from 1 to 12) for any location on the surface of the Earth, and for an integration time of 1 minute.

Annex 1

Prediction method to derive the rainfall rate exceeded for a given average annual and monthly probability of exceedance at a given location

This method predicts the rainfall rate exceeded for a specified average annual exceedance probability, as well as the rainfall rate exceeded for a specified monthly probability at a particular location on Earth's surface. It utilizes digital maps of monthly total rainfall and average monthly surface temperature. The monthly mean total rainfall maps were derived from 50 years (1951-2000) of data from the GPCC Climatology (V 2015) database over land and from 36 years (1979-2014) of the European Centre of Medium-range Weather Forecast (ECMWF) ERA Interim data over water.

The monthly mean total rainfall data, MT_{ii} (mm), where $ii = \{01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11 \text{ and } 12\}$, are an integral part of this Recommendation and are available as digital maps. The latitude grid is from -90.125° N to $+90.125^\circ$ N in 0.25° steps, and the longitude grid is from -180.125° E to $+180.125^\circ$ E in 0.25° steps.

The annual rainfall rate data exceeded for 0.01% of an average year, $R_{0.01}$ (mm/hr), is also an integral part of this Recommendation and are available as digital maps. The latitude grid is from -90° N to $+90^\circ$ N in 0.125° steps, and the longitude grid is from -180° E to $+180^\circ$ E in 0.125° steps.

These digital maps are available in the file P-REC-P.837-8-Maps.zip from the supplement file [R-REC-P.837-8-202509-I!!ZIP-E.zip](#).

Input parameters:

- p : Desired annual probability of exceedance (%)
- Lat : Latitude of the desired location (degrees, N)
- Lon : Longitude of the desired location (degrees, E)

Output parameter:

R_p : Rainfall rate (mm/h) exceeded for the desired probability of exceedance p (%) of an average year.

R_{p_ii} : Rainfall rate (mm/h) exceeded for the desired probability of exceedance p (%) of an average month for any month (ii) of the year.

Step 1: For each month of the year, define the month number, ii , and the number of days in each month, N_{ii} , as follows:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ii	01	02	03	04	05	06	07	08	09	10	11	12
N_{ii}	31	28.25	31	30	31	30	31	31	30	31	30	31

Step 2: For each month number, ii , where $ii = \{01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11 \text{ and } 12\}$, determine the monthly mean surface temperatures, T_{ii} (K), at the desired location (Lat, Lon) from reliable long-term local data.

If reliable long-term local data is not available, the monthly mean surface temperatures, T_{ii} (K), at the desired location (Lat, Lon) can be obtained from the digital maps of monthly mean surface temperature in Recommendation ITU-R P.1510.

Step 3: For each month number ii , where $ii = \{01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11 \text{ and } 12\}$, determine the monthly mean total rainfall, MT_{ii} (mm), at the desired location (Lat, Lon) from reliable long-term local data.

If reliable long-term local data is not available, the monthly mean total rainfall at the desired location (Lat, Lon) can be determined from the digital maps of monthly mean total rainfall, MT_{ii} (mm), provided as an integral part of this Recommendation as follows:

- determine the four grid points (Lat_1, Lon_1), (Lat_2, Lon_2), (Lat_3, Lon_3) and (Lat_4, Lon_4) surrounding the desired location (Lat, Lon);
- determine the monthly mean total rainfall, $MT_{ii,1}$, $MT_{ii,2}$, $MT_{ii,3}$, and $MT_{ii,4}$ at the four surrounding grid points of the maps provided with this Recommendation;
- determine MT_{ii} at the desired location (Lat, Lon) by performing a bi-linear interpolation using the four surrounding grid points as described in Annex 1 Paragraph 1b of Recommendation ITU-R P.1144.

Step 4: For each month number, ii , convert T_{ii} (K) to t_{ii} (°C).

Step 5: For each month number, ii , calculate r_{ii} as follows:

$$\begin{aligned} r_{ii} &= 0.5874e^{0.0883 \times t_{ii}} & \text{for } t_{ii} \geq 0^\circ\text{C} \\ r_{ii} &= 0.5874 & \text{for } t_{ii} < 0^\circ\text{C} \end{aligned} \quad (\text{mm/hr}) \quad (1)$$

Step 6a: For each month number, ii , calculate the monthly probability of rain as follows:

$$P_{0ii} = 100 \frac{MT_{ii}}{24 \times N_{ii} \times r_{ii}} (\%) \quad (2)$$

Step 6b: For each month number, ii , if $P_{0ii} > 70$, set $P_{0ii} = 70$ and $r_{ii} = \frac{100}{70} \times \frac{MT_{ii}}{24N_{ii}}$

Step 7: Calculate the annual probability of rain, $P_{0annual} = P(R > 0)$ as follows:

$$P_{0annual} = \frac{\sum_{ii=1}^{12} N_{ii} \times P_{0ii}}{365.25} \quad (3)$$

Step 8: Rainfall rate statistics can be predicted on an annual or monthly basis. To obtain monthly statistics, follow Step 8a; for annual statistics, use Step 8b.

Step 8a: Prediction of monthly statistics of rainfall rate

If the desired monthly rainfall rate probability of exceedance, p , is greater than P_{0ii} , the rainfall rate at the desired monthly rainfall rate probability of exceedance, R_{p_ii} is 0 mm/hr.

If the desired monthly rainfall rate probability of exceedance (p), is less than or equal to P_{0ii} , adjust the rainfall rate, R_{ref} , by minimizing the absolute value of the relative error between the monthly rainfall rate probability of exceedance, $P_{ii}(R > R_{ref})$, and the desired monthly rainfall rate probability of exceedance, p , until it is less than 0.001% (i.e. until $100 \left| \frac{P_{ii}(R > R_{ref})}{p} - 1 \right| < 0.001$), where:

$$P_{ii}(R > R_{ref}) = P_{0ii} Q \left(\frac{\ln(R_{ref}) + 0.7938 - \ln(r_{ii})}{1.26} \right) \quad (4)$$

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-\frac{t^2}{2}} dt \quad (5)$$

At the end of the minimization process, set $R_{p_ii} = R_{ref}$.

Step 8b: Prediction of annual statistics of rainfall rate

If the desired annual rainfall rate probability of exceedance, p , is greater than $P_{0annual}$, the rainfall rate at the desired annual rainfall rate probability of exceedance, R_p , is 0 mm/hr.

If the desired annual rainfall rate probability of exceedance, p , is less than or equal to $P_{0annual}$, adjust the rainfall rate, R_{ref} , by minimizing the absolute value of the relative error between the annual rainfall rate probability of exceedance, $P(R > R_{ref})$, and the desired annual rainfall rate probability of exceedance, p , until it is less than 0.001% (i.e. until $100 \left| \frac{P(R > R_{ref})}{p} - 1 \right| < 0.001$), where:

$$P(R > R_{ref}) = \frac{\sum_{ii=1}^{12} N_{ii} P_{ii}(R > R_{ref})}{365.25} \quad (\%) \quad (6)$$

$$P_{ii}(R > R_{ref}) = P_{0ii} Q \left(\frac{\ln(R_{ref}) + 0.7938 - \ln(r_{ii})}{1.26} \right) \quad (\%) \quad (7)$$

and

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-\frac{t^2}{2}} dt \quad (8)$$

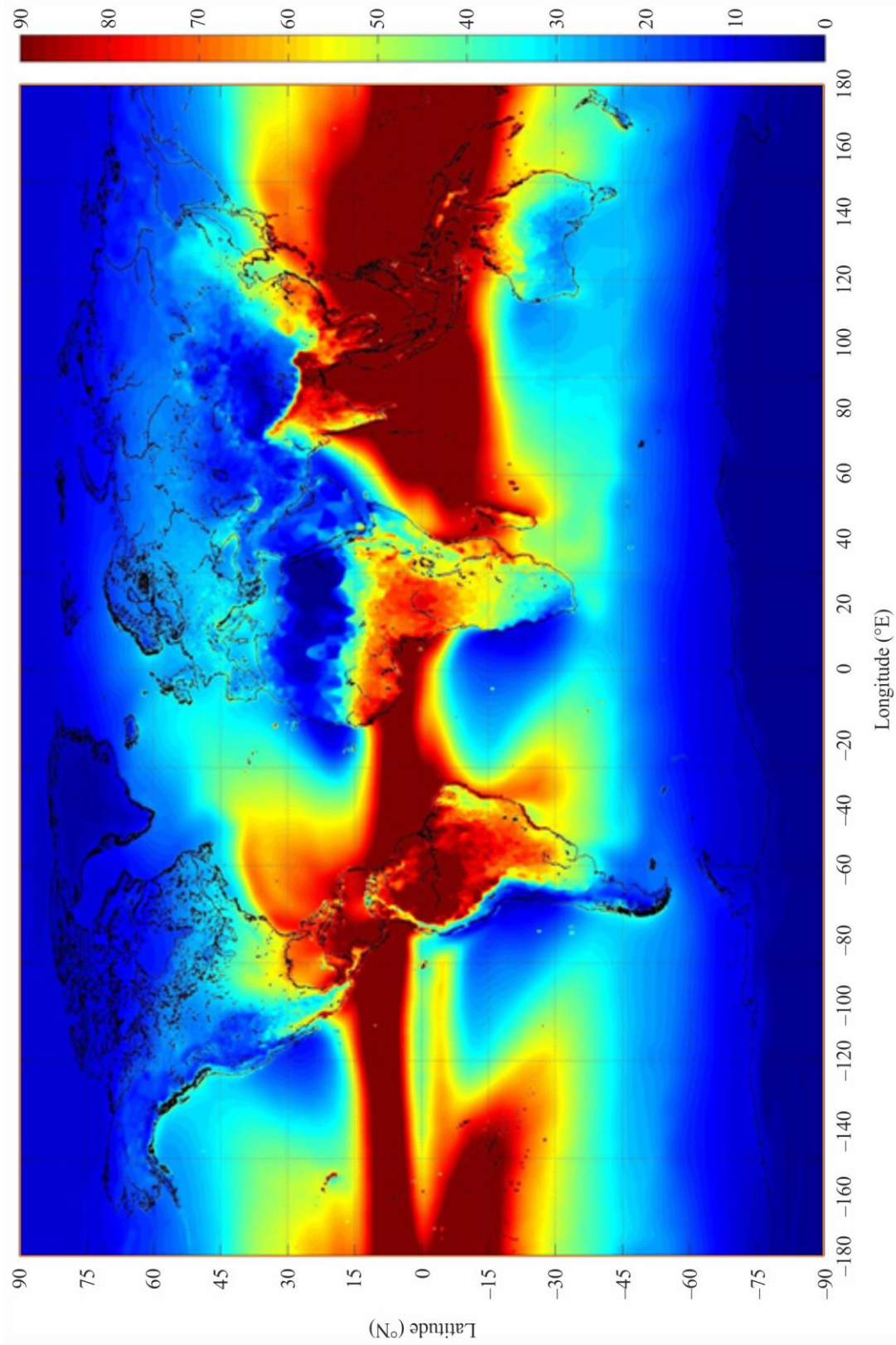
At the end of the minimization process, set $R_p = R_{ref}$.

NOTE 1 – When the 0.01% average annual probability of exceedance is required, and where memory and computational complexity are considerations, the pre-computed map of $R_{0.01}$ can be used with insignificant loss in accuracy. If this map is used, the rainfall rate at the 0.01% average annual probability of exceedance at any desired location on the surface of the Earth can be calculated by performing a bi-linear interpolation using the method described in Annex 1, Paragraph 1b of Recommendation ITU-R P.1144. The absolute value of the difference between the full rainfall rate prediction method and the pre-computed $R_{0.01}$ map is less than 0.3 mm/hr for greater than 99.9% of the surface of the Earth, and the absolute value of the difference between the full rainfall rate prediction method and the $R_{0.01}$ map is less than 1 mm/hr for greater than 99.99% of the surface of the Earth.

NOTE 2 – In the full rainfall rate prediction method, the pre-computed annual map of $R_{0.01}$, representing the rainfall rate at the 0.01% exceedance probability could be used as the initial starting point R_{ref} for the minimization procedure described in both Steps 8a and 8b.

For reference, a map of $R_{0.01}$, the annual rainfall rate exceeded for 0.01% of an average year, is shown in Fig. 1.

FIGURE 1
Rainfall rate exceeded for 0.01% of an average year



Annex 2

- 1 The cumulative distribution of rainfall rate at 1-min integration time can be obtained by converting local cumulative distributions measured at integration times of between 5 and 60 minutes.
 - 2 The recommended method requires as input both the cumulative distribution as well as the integration time of the source rainfall statistics and the geographical coordinates of the site of interest.
 - 3 The method is based on the simulated movement of synthetic rain cells, whose parameters derive from the local input data and ECMWF products.
 - 4 The recommended method is incorporated in a computer program available at the Supplement. The name of the software package implementing this part of the Recommendation is P-REC-P.837-8-Convrrstat.zip from the supplement file [R-REC-P.837-8-202509-I!!ZIP-E.zip](#).
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