RECOMMENDATION ITU-R P.841-4

Conversion of annual statistics to worst-month statistics

(Question ITU-R 201/3)

(1992-1999-2001-2003-2005)

The ITU Radiocommunication Assembly,

considering

a) that for design of radiocommunication systems the required statistics of propagation effects pertain to the worst-month period of reference;

b) that the reference statistics for many radiometeorological data and propagation prediction methods is "the long-term average annual" distribution;

c) that consequently there is a need for a model that provides for the conversion of the "annual" to the "worst-month" statistics,

recommends

1 that the model given in Annex 1 be used for the conversion of the average annual time percentage of excess to the average annual worst-month time percentage of excess.

Annex 1

1 The average annual worst-month time percentage of excess, p_w, is calculated from the average annual time percentage of excess p by use of the conversion factor Q:

$$p_w = Q\,p \qquad (1)$$

where $1 \le Q \le 12$, and both p and p_w refer to the same threshold levels.

2 Q is a two parameter (Q_1, β) function of p (%):

$$Q_{(p)} = \begin{cases} 12 & \text{for} \quad p < \left(\frac{Q_1}{12}\right)^{\frac{1}{\beta}} \% \\ Q_1\, p^{-\beta} & \text{for} \quad \left(\frac{Q_1}{12}\right)^{\frac{1}{\beta}} < p \le 3\% \\ Q_1\, 3^{-\beta} & \text{for} \quad 3\% < p \le 30\% \\ Q_1\, 3^{-\beta} \left(\frac{p}{30}\right)^{\frac{\log\left(Q_1\, 3^{-\beta}\right)}{\log(0.3)}} & \text{for} \quad 30\% < p \end{cases} \qquad (2)$$

3 The calculation of the average annual time percentage of excess from the given value of the average annual worst-month time percentage of excess is done through the inverse relationship:

$$p = p_w / Q \tag{3}$$

and the dependence of Q on p_w can be easily derived from the above given dependence of Q on p. The resulting relationship for $12\, p_0 < p_w(\%) < Q_1\, 3^{(1-\beta)}$ is ($p_0 = (Q_1/12)^{1/\beta}$):

$$Q = Q_1^{1/(1-\beta)}\, p_w^{-\beta/(1-\beta)} \tag{4}$$

4 For global planning purposes the following values for the parameters Q_1 and β should be used:

$$Q_1 = 2.85, \quad \beta = 0.13$$

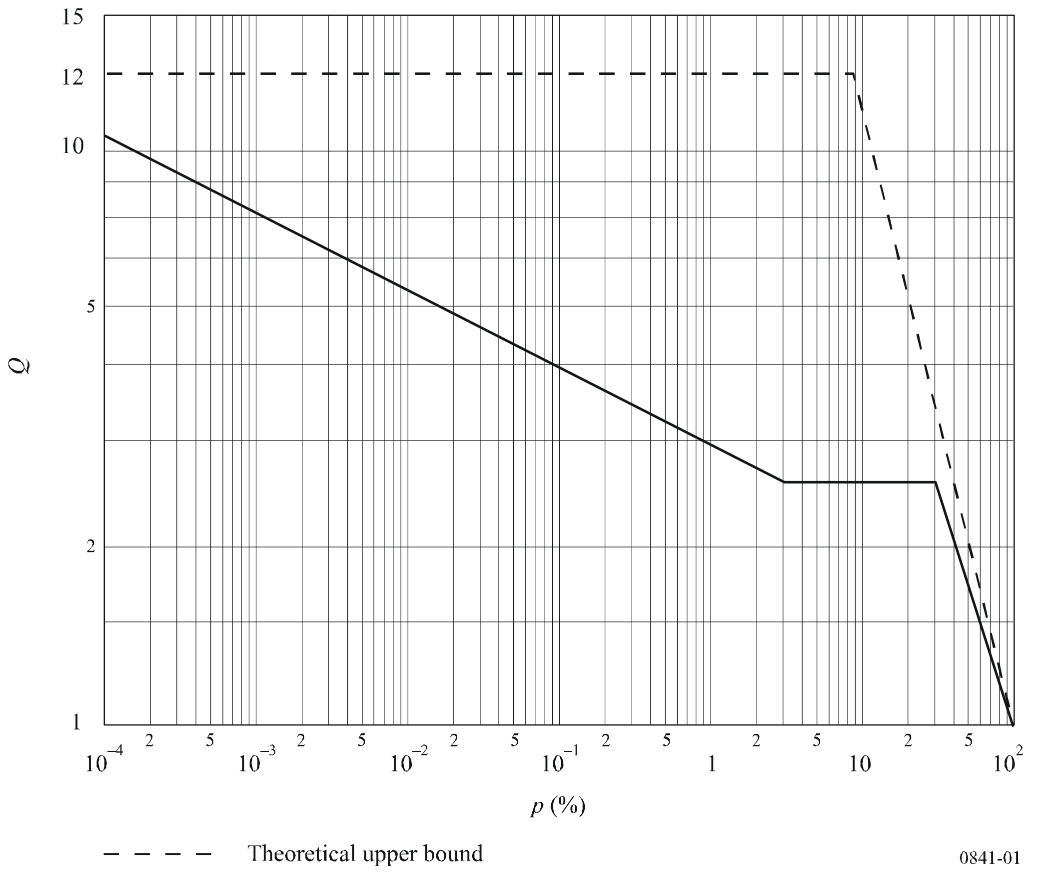
(see Fig. 1). This leads to the following relationship between p and p_w:

$$p(\%) = 0.30\; p_w(\%)^{1.15} \tag{5}$$

for $1.9 \times 10^{-4} < p_w(\%) < 7.8$.

FIGURE 1

Example of the dependence of Q on p (solid line) with parameter values Q_1 = 2.85 and β = 0.13



For global rain rate applications, the following values for the parameters Q_1 and β should be used:

$Q_1 = 2.82$, $\beta = 0.15$, for tropical, subtropical and temperate climate regions with frequent rain $Q_1 = 4.48$, $\beta = 0.11$, for dry temperate, polar and desert regions (see Fig. 2). This leads to the following relationship between p and p_w:

$$p(\%) = 0.30 p_w(\%)^{1.18} \tag{6}$$

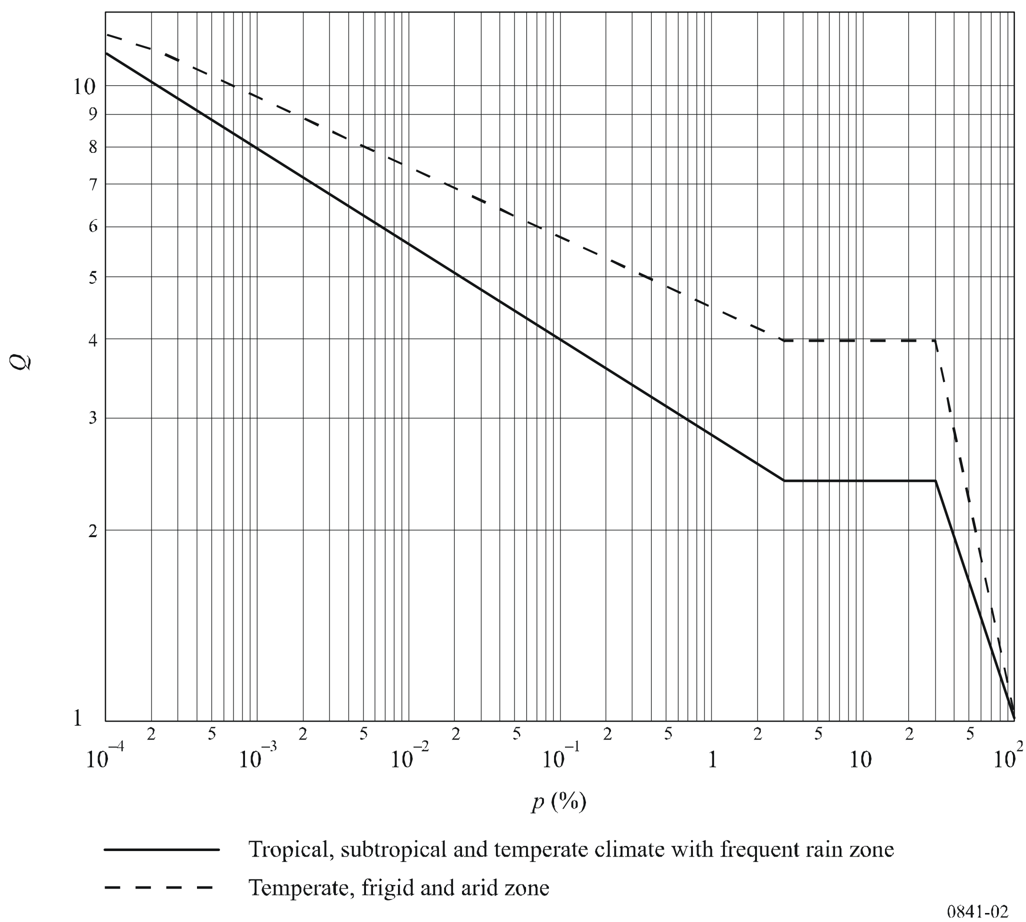
where $7.7 \times 10^{-4} < p_w(\%) < 7.17$, for tropical, subtropical and temperate climate regions with frequent rain:

$$p(\%) = 0.19 p_w(\%)^{1.12} \tag{7}$$

where $1.5 \times 10^{-3} < p_w(\%) < 11.91$, for dry temperate, polar and desert regions.

FIGURE 2

Example of the dependence of *Q* on *p* with global subregion parameters



5 For more precision the values of Q_1 and β for the different climatic regions and various propagation effects given in Table 1 should be used where appropriate.

6 For trans-horizon mixed paths, the β and Q_1 values are calculated from those values for sea and land given in Table 1, through linear interpolation using the fractions of the link traversing sea and land respectively as weights.

7 Entries under rain rate for Australia are based on 6-min time interval measurements taken from 20 sites over periods lasting from 25 to 101 years. Examples of site locations for each climatic region in Australia are given in the first column of Table 1. Entries under rain rate for Brazil have been derived for measurements of rainfall rates at nine sites over a 46-year period using fast response rain gauges.

TABLE 1

β and Q_1 values for various propagation effects and locations

	Rain effect terrestrial attenuation	**Rain effect slant path attenuation**	**Rain rate**	**Multipath**	**Trans-horizon land**	**Trans-horizon sea**
Global	0.13, 2.85	0.13, 2.85		0.13, 2.85	0.13, 2.85	0.13, 2.85
Tropical, subtropical and temperate climate regions with frequent rain			0.15, 2.82			
Dry temperate, polar and desert regions			0.11, 4.48			
Europe North West	0.13, 3.0	0.16, 3.1		0.13, 4.0	0.18, 3.3	
Europe North West 1.3 GHz						0.11, 4.9
Europe North West 11 GHz						0.19, 3.7
Europe Mediterranean	0.14, 2.6	0.16, 3.1				
Europe Nordic	0.15, 3.0	0.16, 3.8		0.12, 5.0		
Europe alpine	0.15, 3.0	0.16, 3.8				
Europe Poland	0.18, 2.6					
Europe Russian Federation	0.14, 3.6					
Europe UK 40 and 50 GHz		0.13, 2.54				
Congo	0.25, 1.5					
Canada Prairie and North	0.08, 4.3					

TABLE 1 *(continued)*

	Rain effect terrestrial attenuation	**Rain effect slant path attenuation**	**Rain rate**	**Multipath**	**Trans-horizon land**	**Trans-horizon sea**
Canada Coast and Great Lake	0.10, 2.7					
Canada Central and Mountains	0.13, 3.0					
United States of America Virginia		0.15, 2.7				
Russian Federation North European region			0.10, 4.57			
Russian Federation Central and West European region			0.16, 2.38			
Russian Federation Middle Volga region and South Ural			0.10, 4.27			
Russian Federation Central Steppe and South European region			0.15, 2.69			
Russian Federation West Siberian region			0.14, 3.72			
Russian Federation Middle Siberian Plateau and Jakutia			0.11, 5.04			
Russian Federation South Far East			0.13, 3.53			
Australia Temperate/ coastal			0.17, 2.65			
Australia Subtropical/ coastal			0.15, 3.15			

TABLE 1 *(end)*

	Rain effect terrestrial attenuation	**Rain effect slant path attenuation**	**Rain rate**	**Multipath**	**Trans-horizon land**	**Trans-horizon sea**
Australia Tropical/arid			0.12, 4.35			
Brazil Equatorial			0.13, 2.85			
Brazil Tropical maritime			0.21, 2.25			
Brazil Tropical inland			0.13, 3.00			
Brazil Subtropical			0.13, 2.85			
Indonesia	0.22, 1.7					
Japan Tokyo	0.20, 3.0					
Japan Yamaguchi		0.15, 4.0				
Japan Kashima		0.15, 2.7				
South Korea			0.12, 4.6			
Kyrgyzstan Flat regions			0.09, 5.95			
Kyrgyzstan Mountainous regions			0.10, 6.70			
Kyrgyzstan Coastal region of Ysyk-Kol lake			0.14, 4.73			
China South			0.15, 3.12			
China North			0.13, 4.12			
China Desert			0.10, 5.40			