



Recommendation ITU-R P.835-6
(12/2017)

Reference standard atmospheres

P Series
Radiowave propagation



Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from <http://www.itu.int/ITU-R/go/patents/en> where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Recommendations

(Also available online at <http://www.itu.int/publ/R-REC/en>)

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	Radiowave 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.835-6

Reference standard atmospheres

(Question ITU-R 201/3)

(1992-1994-1997-1999-2005-2012-2017)

Scope

Recommendation ITU-R P.835 provides expressions and data for reference standard atmospheres required for the calculation of gaseous attenuation on Earth-space paths.

The ITU Radiocommunication Assembly,

considering

a) the necessity for a reference standard atmosphere for use in calculating gaseous attenuation along an Earth-space path,

recommends

1 that the standard atmospheres in Annex 1 be used to determine temperature, pressure and water-vapour pressure as a function of altitude, for calculating gaseous attenuation when more reliable local data are not available;

2 that the experimental data in Annexes 2 and 3 be used for the locations of interest when seasonal and monthly variations are concerned.

Annex 1**1 Mean annual global reference atmosphere**

The following mean annual global reference atmosphere reflects the mean annual temperature and pressure profiles vs. height when averaged across the globe.

1.1 Temperature and pressure

The mean annual global reference atmosphere approximates the U.S. Standard Atmosphere, 1976 with insignificant relative error. The atmospheric temperature and pressure profiles are defined in two height¹ regimes: 1) geopotential heights from 0 km' to 84.852 km', and 2) geometric heights from 86 km to 100 km. The conversions between geopotential height, h' (km), and geometric height, h (km), are:

$$h' = \frac{6356.766h}{6356.766+h} \quad (1a)$$

and

$$h = \frac{6356.766h'}{6356.766-h'} \quad (1b)$$

¹ km' are units of geopotential height, and km are units of geometric height.

where a geopotential height of 84.852 km' corresponds to a geometric height of 86 km. Since various P-series Recommendations (e.g. Recommendation ITU-R P.676 Annex 1) use geometric height, the temperature and pressure at a geometric height $h \leq 86$ km can be calculated by converting geometric height h to the corresponding geopotential height h' and calculating the temperature and pressure at the corresponding geopotential height h' .

In the first height regime, the temperature T (K) at geopotential height h' (km') is:

$$T(h') = 288.15 - 6.5 h' \quad \text{for } 0 \leq h' \leq 11 \quad (2a)$$

$$T(h') = 216.65 \quad \text{for } 11 < h' \leq 20 \quad (2b)$$

$$T(h') = 216.65 + (h' - 20) \quad \text{for } 20 < h' \leq 32 \quad (2c)$$

$$T(h') = 228.65 + 2.8 (h' - 32) \quad \text{for } 32 < h' \leq 47 \quad (2d)$$

$$T(h') = 270.65 \quad \text{for } 47 < h' \leq 51 \quad (2e)$$

$$T(h') = 270.65 - 2.8 (h' - 51) \quad \text{for } 51 < h' \leq 71 \quad (2f)$$

$$T(h') = 214.65 - 2.0 (h' - 71) \quad \text{for } 71 < h' \leq 84.852 \quad (2g)$$

and the pressure P (hPa) at geopotential height h' (km') is:

$$P(h') = 1013.25 \left[\frac{288.15}{288.15 - 6.5 h'} \right]^{-34.1632/6.5} \quad \text{for } 0 < h' < 11 \quad (3a)$$

$$P(h') = 226.3226 \exp[-34.1632 (h' - 11)/216.65] \quad \text{for } 11 < h' \leq 20 \quad (3b)$$

$$P(h') = 54.74980 \left[\frac{216.65}{216.65 + (h' - 20)} \right]^{34.1632} \quad \text{for } 20 < h' \leq 32 \quad (3c)$$

$$P(h') = 8.680422 \left[\frac{228.65}{228.65 + 2.8 (h' - 32)} \right]^{34.1632/2.8} \quad \text{for } 32 < h' \leq 47 \quad (3d)$$

$$P(h') = 1.109106 \exp[-34.1632 (h' - 47)/270.65] \quad \text{for } 47 < h' \leq 51 \quad (3e)$$

$$P(h') = 0.6694167 \left[\frac{270.65}{270.65 - 2.8 (h' - 51)} \right]^{-34.1632/2.8} \quad \text{for } 51 < h' \leq 71 \quad (3f)$$

$$P(h') = 0.03956649 \left[\frac{214.65}{214.65 - 2.0 (h' - 71)} \right]^{-34.1632/2.0} \quad \text{for } 71 < h' \leq 84.852 \quad (3g)$$

In the second height regime, the temperature T (K) at geometric height h (km) is:

$$T(h) = 186.8673 \quad \text{for } 86 \leq h \leq 91 \quad (4a)$$

$$T(h) = 263.1905 - 76.3232 \left[1 - \left(\frac{h-91}{19.9429} \right)^2 \right]^{\frac{1}{2}} \quad \text{for } 91 < h \leq 100 \quad (4b)$$

and the pressure P (hPa) at geometric height h (km) is:

$$P(h) = \exp(a_0 + a_1 h + a_2 h^2 + a_3 h^3 + a_4 h^4) \quad \text{for } 86 \leq h \leq 100 \quad (5)$$

where

$$a_0 = 95.571899$$

$$a_1 = -4.011801$$

$$a_2 = 6.424731 \times 10^{-2}$$

$$a_3 = -4.789660 \times 10^{-4}$$

$$a_4 = 1.340543 \times 10^{-6}$$

For reference, the temperature and pressure vs. geometric height are shown in Figs 1 and 2, respectively.