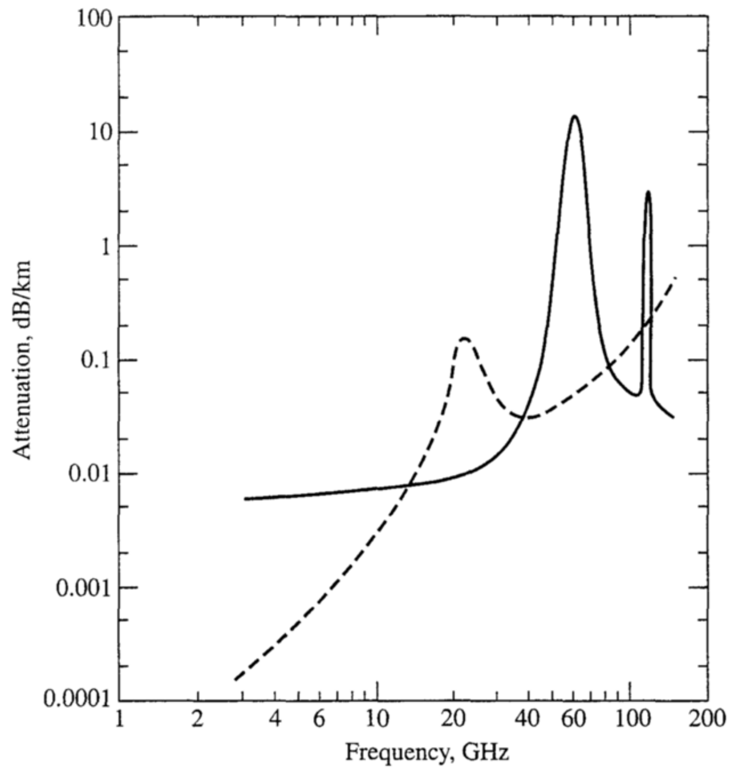
Atmospheric Attenuation

Attenuation of electromagnetic energy in the atmosphere. Solid curve is due to absorption by oxygen. Dashed curve is due to absorption by water vapor.



We modifying radar equations to account for attenuation by multiplying numerator with factor exp(-2αR) where α is the one-way the attenuation coefficient in the same units of distance^{-1}, and R is the range to the target. For example, the radar equation for distributed targets:

$$P_r = \left(\frac{G^2 \lambda^2 P_t \theta \phi c \tau}{1024 \ln(2) \pi^2} \right) \frac{\eta}{R^2} = C \frac{\eta}{R^2}$$

becomes:

$$P_r = \left(\frac{G^2 \lambda^2 P_t \theta \phi c \tau}{1024 \ln(2) \pi^2} \right) \frac{\eta}{R^2} e^{-2\alpha R} = C \frac{\eta}{R^2} e^{-2\alpha R}$$

The other radar equations are modified the same way. If α is not constant, but a function of distance, then we use exp(-2$\int \alpha(R) dR$.

Important Note: The figure above is the attenuation and **not** the attenuation coefficient α. What is plotted in the figure is equivalent to 4.34α.

Problem. Show that the relationship between attenuation in dB/km and attenuation coefficient is

Attenuation in dB per unit distance = 4.34×attenuation coeffiecient

Question. Using the figure above, what is the one-way total atmospheric attenuation for a K-band radar at 22 GHz? over a distance of 20 km?

Answer. At 22 GHz there is a peak in the water vapor absorption and the attenuation (broken curve) is about 0.2 dB/km. The attenuation due to oxygen is about 0.01 dB/km. The attenuation total is then 0.21 dB/km or $0.21\times20 = 4.2$ dB or a factor $1/2.63 = 0.38$. Alternatively, 0.21 dB/km is equivalent to an attenuation coefficient $\alpha = 0.21/4.34 = 0.04839$ km^{-1}. The attenuation is then $\exp(-0.04839\times20) = 0.38$.

Effect of Elevation Angle

Two-way atmospheric attenuation as a function of range and frequency for (a) 0° elevation angle and (b) 5° elevation angle.