(1) How far from a 1-kW radio transmitter is the rms electric field strength equal to that in the cosmic microwave background?

One square meter of black surface at temperature T radiates $6 \times 10^{-8} T^4$ W. (One-page handbook, January.) For $T = 2.7$ K, the apparent temperature of the cosmic background, that amounts to 3×10^{-7} W/m^2. The energy density in the isotropic radiation field will be $4/c$ times that, or $(1.2 \times 10^{-6}/c)$ J/m^3. One kilometer away from the radio transmitter, if its power is spread over a hemisphere, we would have 10^3 W over 6×10^6 m^2 or 1.7×10^{-4} W/m^2. This is unidirectional, so the energy density is only $1/c$ (not $4/c$) times 1.7×10^{-4}. The distance from the transmitter in kilometers at which the energy densities, and hence the rms field strengths, would be equal is therefore $(1.7 \times 10^{-4}/1.2 \times 10^{-6})^{1/2}$, or 12 km. If you are surprised that it is not much greater, consider the following statement which is also true: At all wavelengths longer than 1 mm the Earth receives more energy from the cosmic background radiation than it does from the sun. (Remember that a 6000-K surface is only 2000 times brighter at millimeter wavelengths than a 3-K surface, and the sun fills less than 1/2000 of the sky!)