THE EFFECT OF TERRAIN OBSTACLES IN GROUND-BASED TROPOSPHERIC DUCTS

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1. INTRODUCTION

Interference between the earth station of a satellite link and terrestrial microwave systems is an important question to be considered in frequency sharing and coordination studies. To reduce the possibility of interference, the earth station is usually located in a place surrounded by natural obstacles. This site shielding effect can be very effective in normal propagation conditions. However, as shown by Misme [1] a few years ago, in the case of strong fields due to a surface duct the effectiveness of this solution can be seriously damaged. This paper describes a mathematical model to be used in the estimation of the site shielding effect when the interfering path is within a ground-based tropospheric duct.

2. MATHEMATICAL MODEL

The experimental observation of the diffraction by an obstacle within a tropospheric duct shows a gain effect,i.e., the attenuation is lower than that one measured in the absence of the duct. Although the rigorous solution of this problem is very complex (mode theory), an approximate solution can be easily derived from geometrical optics.

The basic geometry for the mathematical model discussed here is shown in figure 1. The earth station is usually not far from the obstacle, only a few kilometers apart. In general, this distance is lesser than the duct coupling minimum distance and the propagation between earth station and obstacle top can be considered as free-space [2]. The earth station is represented by the terminal R in figure 1.

The proposed solution considers only the direct ray (TOR) , the earth reflected ray (TAOR) and the duct upper layer reflected ray (TBOR). Paths with two or more reflections are neglected. This procedure is based in the assumption that ray magnitude after sucessive reflections is largely reduced. Then, the modulus of the receiving field is given by,

$$|E| = E_o \left| \sum_i A_i \, e^{j\psi_i} \right| \tag{1}$$

where E_o is the free-space field and A_i, ψ_i correspond to the amplitude and phase of the ray of order i, respectively. The earth reflected ray is relevant only in the case of a smooth terrain. The reflection coefficient of the duct upper layer is given by [3],

$$R_c = j \exp\left(-j \frac{2k_o}{3\alpha} \operatorname{sen}^3\theta\right) \tag{2}$$

where

$k_o = \frac{2\pi}{\lambda}$; λ = wavelength

$\alpha = -\frac{dn_m}{dh}$; n_m = modified index of refraction

θ = incident angle in the duct upper layer.

3. NUMERICAL RESULTS

The model described in the previous section will be now applied to explain the experimental results observed by Misme in the Mediterranean region [1]. According to Misme, duct occurrence in this region is around 7% of the year, with an average height of 400 meters. Details about the experimental link is shown in figure 2. As the operating frequency was 6 GHz, it is reasonable admit that the obstacle behaves as a knife-edge. It was supposed total reflection in the sea (reflection coefficient equal to - 1). The reflection coefficient of the upper layer was estimated in using the gradient of the modified index of refraction exceeded for 0.1% of the year.This percentage seems to be representative to characterize the site shielding level observed experimentally. Then, the parameter α in (2) is given by,

$$\alpha = 8 \times 10^{-8} \ m^{-1}$$

Introducing the above data in (1) and (2) and also taking into account the geometry of figures 1 and 2, the theoretical calculation of the site shielding factor leads to 19.2 dB. Considering that the measured value was 18dB, the mathematical model proves to be useful to explain this result. It must be remarked that in the absence of the duct the attenuation due to the obstacle is about 28.7 dB.

4. CONCLUDING REMARKS

A mathematical model to evaluate the site shielding effect of an obstacle within a ground-based duct was presented. Comparison between theoretical and experimental results were satisfactory. However, as only one experimental link was available, further studies should be carried out to confirm the effectiveness of the theoretical model.

5. REFERENCES

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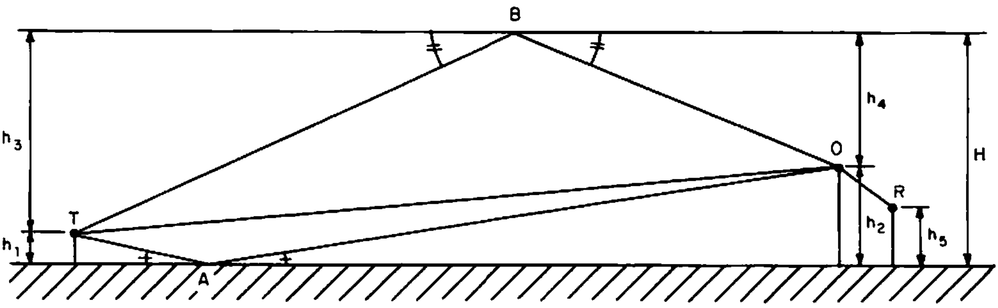

Figure 1

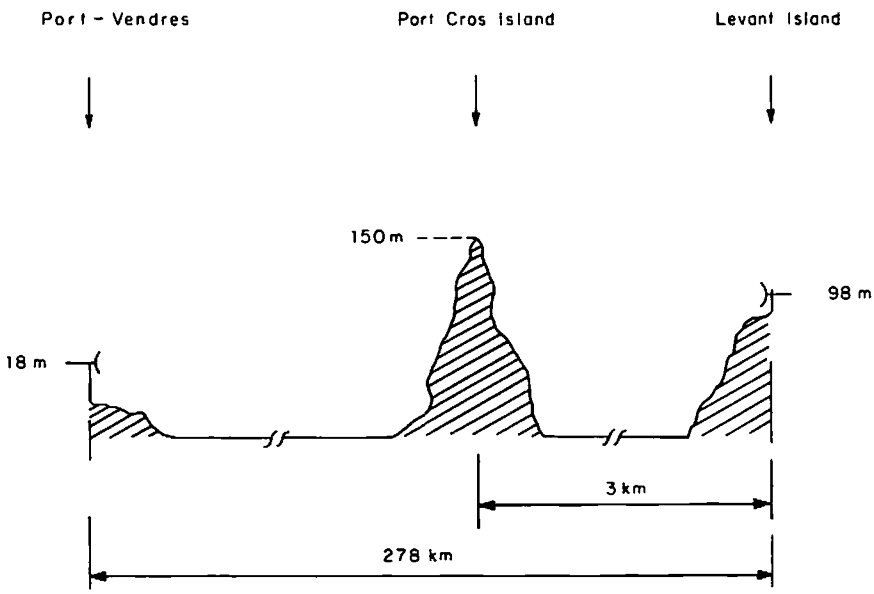

Figure 2