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STATISTICS OF THE HYDROMETEOR ATTENUATION AT VISIBLE AND INFRARED WAVELENGTHS ON TERRESTRIAL PATHS

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Meteorological conditions have a sufficient influence on the propagation distance at visible and infrared wavelengths on the terrestrial paths.

At present it is established [1] that one can select the wavelengths in the transparent windows for that the attenuation caused by the molecular absorption would not exceed a few dB/km. In this case the transmission distance will be limited by the hydrometeor attenuation (for example fog, rain, snow etc.) The number of models of terrestrial laser communication link is developed for transmission distance up to a few kilometers [2] . One needs know about the statistical characteristics of the hydrometeor attenuation in the certain climate area for the communication link reliabilities to estimate.

The correlation between the attenuation coefficients (γ) and the meteorological hydrometeor parameters such as a visibility range (Sm), a liquid water content and a rain rate is obtained by means of propagation studies at visible and infrared wavelengths. It is possible to get the

temporal attenuation distribution in any climate area on the base of frequencies of the hydrometeor characteristics obtained owing to meteorological observation for a long time [3].

In the Table 1 [4] is given the duration of the various meteorological conditions (P%) in per cent according to observation time for 10 years (1961-71) taken as 100% on the "Podmoskovnaya" meteostation area.

Table 1

Meteorological phenomenon	Rain	Snow	Fog	Mist	Clear
P%	2,1	6,9	5,3	49,5	36,4

In these wheather phenomena the frequencies of different intervals of Sm from Sm < 50 m to Sm > 50 km are established. The statistics about visibility frequencies is enough for obtaining of the probability characteristics of attenuation in the visible region [5]. In the further consideration we shall deal with the helium-neon laser wavelength (0,63 μm) in the visible range and the carbon dioxide laser wavelength (10,6 μm) in the infrared range.

It follows from the temporal distribution of attenuation at 0,63 μm obtained on the base of the visibility data that the attenuation more than 100 dB/km occurs for less than 0,4% of time in the "Podmoskovnaya" meteostation area and it is caused by heavy fog. On the whole the attenuation in the visible range more than 30 dB/km caused by

fog and precipitation can be occured about for 1% a year.

For a transition from Sm or γ 0,63 to the attenuation at 10,6 μm it is helpful to make use of a correlation between γ 0,63 and γ 10,6 obtained by means of simultaneous measurements of the attenuation coefficient for the various hydrometeors. In the case of droplet hydrometeors one can derive this correlation on the base of hydrometeor microstructure measurements and γ 0,63 and γ 10,6 calculations by use of Mie theory.

The correlation is given in the following form

$$\gamma 10,6 = k \gamma 0,63 , \qquad (1)$$

where k is the coefficient of regression. The experimental values of k for fog, rain and snow are given in the Table 2 [1,3,6] . The value for mist given in the Table 2 is calculated for the case of mist microstructure occured most frequently.

Table 2

Hydrometeors	Mist	Fog	Rain	Snow
K	$3,12.10^{-2}$	$0,38 \pm 0,2$	$1,0 \pm 0,2$	$1,38 \pm 0,13$

Since Mie parameter $\rho = 2\pi a/\lambda$ (a-particle size and λ-wavelength) is usually less than 5 in the case of mist or fog particle sizes and $\lambda = 10,6$ μm, the attenuation efficiency factor depends on the particle size.

The coefficients γ 10,6 will be different at the same value of visibility range in accordance with the microstructure. The influence of fog microstructure on k was investigated in details in artifical water aerosol [1,6] . It is shown that k is practically proportional to the mean radius of drop in polydisperse aerosol.

On the base of the temporal distribution of γ 0,63 and (1) one can calculate the attenuation frequency at 10,6 μm for the certain hydrometeors and then estimate the total probability distribution of attenuation on the terrestrial path. The temporal distribution established in this way shows that γ 10,6 is less than at the visible region during 75% of time in the "Podmoskovnaya" meteostation area.

It is interesting to compare the probability distributions of γ 10,6 and γ 0,63 calculated on the base of the data about the visibility range frequencies with those obtained directly from the measurement of attenuation at these wavelengths for a long time. The comparison was made in the case of the visibility observation in snow during 400 h and the measurements of attenuation at 0,63 and 10,6 μm due to snow on the 1,36 km path for 30h.

During 75% of time characterizing the probability of attenuation less than 10 dB/km, both distribution proved to coincide well. The medium values were equal to 6 dB/km in the both cases.

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