ON SATURATION OF LASER SIGNAL FLUCTUATIONS IN SNOWFALL RECORDED BY A NONPOINT RECEIVER

N.A. Vostretsov and A.F. Zhukov

Institute of Atmospheric Optics,
Siberian Branch of the Russian Academy of Sciences, Tomsk
Received July 29, 1994

Dependence of the level of laser signal fluctuations in snowfall on the receiver diameter, optical thickness of precipitation, and maximum size of snowflakes has been studied experimentally. The level of saturation (σ_s) and optical thickness (τ_s) at which the saturation occurs increase with maximum size of snowflakes (D_m) when the receiver diameter is 3.1 mm. *At the same time τ_s decreases with the increase of the receiver diameter for close values of snowflakes size.*

Saturation of laser signal fluctuations in snowfall recorded by a point receiver of diameter 0.1 or 0.3 mm was studied in Refs. 1 and 2. This naturally brings up the question: what becomes of the signal when the receiver diameter increases?

We measured the level of laser signal fluctuations on (2×130) m path for three diameters of the receiver D = 0.1, 0.8, and 3.1 mm. Measurements were made in winter of 1993–1994 in a narrow diverging beam of an LGN–215 He–Ne laser at λ = 0.63 μm. The divergence angle was $5\cdot 10^{-4}$ rad. Measurement procedure and instrumentation were described in Ref. 1. Measurements were made during 21 snowfalls at different optical thickness τ with maximum size of snowflakes D_m.

Figure 1 depicts variations in the mean values of the fluctuation level σ with the increase of the optical thickness, recorded with the receiver 3.1 mm in diameter for three values of maximum size of snowflakes. The mean values σ were obtained by averaging of the measured values σ over τ with a 0.1 step. The vertical bar in the figure shows the maximum standard deviation for σ that characterizes their spread. From the figure, it is apparent that σ, for fixed path length and receiver diameter, depends on two independent parameters τ and D_m.

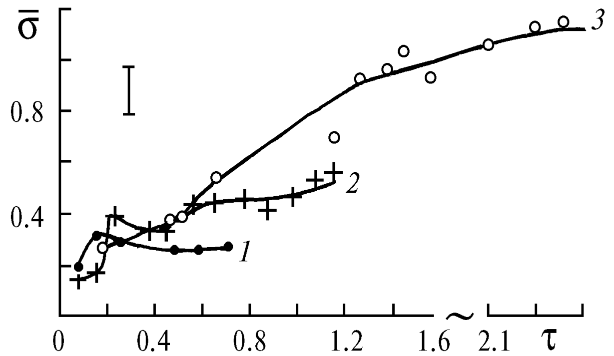

FIG. 1. Average values of fluctuation level σ vs optical depth τ for D = 3.1 mm: D_m = 1 mm (1), 1–3 mm (2), and 5 – 10 mm (3).

It should be noted that for close values of D_m with the increase of optical thickness τ the level of fluctuations σ first increases and then tends to saturation at a certain level σ_s that increases with maximum size of snowflakes. It is also significant that with the increase of maximum size of snowflakes the optical thickness τ_s at which saturation occurs increases.

For the receiver diameters 0.1 and 0.8 mm, the optical thickness on 260 m path did not exceed unity. This gives us no way to determine with confidence the values of σ_s and τ_s in these cases. For this reason the data on σ_s and τ_s for D = 0.1 mm were borrowed from Refs. 1 and 2 for L > 260 m. As to D = 0.8 mm, the values σ_s and τ_s for this receiver must be taken as estimates.

Table I lists the values of σ_s and τ_s derived from the plots for three values of D and different D_m. The results presented in Table I for D = 0.1 and 0.8 mm are in qualitative agreement with those for D = 3.1 mm. Moreover, there are some interesting relations between the data in Table I for both σ_s and τ_s.

TABLE I.

D_m, mm	D = 3.1 mm		D=0.1 mm (Ref. 2)		D = 0.8 mm	
	σ_s	τ_s	σ_s	τ_s	σ_s	τ_s
1	0.28	0.25	–	–	0.4	0.4
1–3	0.45	0.65	0.75	2.0	0.6	0.7
3–5	0.55	0.72	0.90	2.2	–	–
5–10	1.00	1.40	–	–	–	–

The ratio $\sigma_s(D$ = 0.1 mm$)/\sigma_s(D$ = 3.1 mm$)$ for D_m = 1–3 mm equals 1.66 and approaches the corresponding ratio for D_m = 3–5 mm. Moreover, the ratios $\tau_s(D$ = 0.1 mm$)/\tau_s$(3.1 mm) for the two aforementioned ranges of variation of D_m are in fact equal and approach three.

The physical meaning of these three agreements has yet to be understood. The decrease of σ with D increase is well explicable. To elucidate the behavior of the function $\sigma = F(D, D_m, \tau)$, measurements must be made for a wider range of D and τ variations.

REFERENCES

1. A.F. Zhukov, M.V. Kabanov, R.Sh. Tsvyk, N.A. Vostretsov, and N.P. Krivolapov, Atm. Opt. **4**, No. 4, 272–275 (1991).
2. A.F. Zhukov, Atm. Oceanic Opt. **6**, No. 1, 19–21 (1993).

0235-6880/95/05 414-01 $02.00