ON SOME OPTICAL PROPERTIES OF THE ATMOSPHERE OF THE LIBYAN DESERT

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In October–November 1957, in connection with the program of the International Geophysical Year, observations were carried out by me and my collaborators in the Egyptian region of the UAR. Our expedition was located in the Libyan Desert south of Aswan ($\varphi = 23°59', \lambda = 32°52'$), at a distance of 1 km from the Nile River and approximately 200 km west of the Red Sea.

It was established that the optical properties of the atmosphere are very stable in the forenoon and afternoon hours; nevertheless, this stability was disturbed for several hours around noon, after which the atmosphere became more transparent than before noon, a phenomenon observed very rarely under the conditions of the USSR. The circumsolar aureole diminished in the afternoon hours in comparison with its forenoon values. Meanwhile, at the observing site the wind direction did not change (throughout the entire period of observations the wind direction was northerly), and the wind force, as a rule, was approximately the same. It is highly probable that the cause of this is a change of wind in the higher layers of the atmosphere; for example, if in the morning hours there was a wind direction from the southeast (from the Indian Ocean), and after noon from the west (from the Sahara), then the indicated change in the transparency of the atmosphere would probably have been observed. Owing to the great stability of the atmosphere, the Bouguer straight line (the logarithm of solar radiation as a function of atmospheric mass) remained undisturbed up to large atmospheric masses ($m = 15$—18).

The atmosphere at the observing site on cloudless days possessed very great homogeneity in optical respect. As an example, Fig. 1 is given, showing two scattering indicatrices obtained on 25 X on the basis of observations of the brightness of the sky along the entire almucantar of the Sun at its zenith distance $z = 74°$. Crosses denote observations to the right of the Sun, dots–to the left of it. It is seen that the two indicatrices differ very little from one another.

Fine atmospheric dust was almost absent, the humidity was low and, probably as a result of this, almost every evening at sunset one could observe the green ray. The increase in transparency after noon affected the polarization properties of the atmosphere. It turned out that the degree of polarization of the daytime sky was always higher after noon than before noon. Hoffmeister (1) also pointed to this same phenomenon for western equatorial Africa.

Polarization, which is a very sensitive indicator of the constancy of the optical properties of the atmosphere, was determined by me in magnitude and direction with the aid of the visual photometer described in (2), equipped with a yellow Schott filter and a polaroid. The method of V. G. Fesenkov (3, 4) was used, which consists in measuring the brightness of some point of the sky through a polaroid at three of its positions, equally spaced from one another by 60°. The degree of polarization P is determined by

formula

$$P = \frac{2\sqrt{\overline{B_1}(B_1 - B_2) + B_2(B_2 - B_3) + B_3(B_3 - \overline{B_1})}}{B_1 + B_2 + B_3}. \quad (1)$$

The angle α between the plane of oscillations of the observed point of the sky and the transmission plane of the polaroid in its first position is found from the formula

$$\operatorname{tg} 2\alpha = \sqrt{3}\,\frac{B_2 - B_3}{2B_1 - B_2 - B_3}, \quad (2)$$

where B_1, B_2, B_3 are the brightnesses of the observed point of the sky at the three indicated positions of the polaroid.

The degree of polarization reached very considerable values. Fig. 2 shows the degree of polarization of the sky at the zenith on 22 XI, with zenith distances of the Sun from $85°32'$ in the morning to $91°31'$ in the evening. As can be seen, the degree of polarization after noon was greater than before noon and, continuing to increase, reached 80% immediately after sunset.

Fig. 3 shows the course of the degree of polarization on the Sun' s almucantar, at an angular distance from the Sun $\vartheta = 90°$, as a function of the atmospheric mass in the direction toward the Sun, m, observed on 16 XI from $z = 87°2'$ in the morning

Fig. 1

Fig. 2

and to $87°34'$ in the evening. On this day the degree of polarization after noon was also greater than before noon, reached 77%, and remained constant as the altitude of the Sun changed.

In the case of first-order scattering of light, the direction of the plane of oscillations must be perpendicular to the plane of vision. The angle β between

Fig. 3

Fig. 4

Figure 1: Fig. 4

the plane of oscillations for points on the Sun' s almucantar and the corresponding vertical can be calculated from the formula

$$\sin\beta = \operatorname{ctg} z \ \operatorname{tg}\frac{\vartheta}{2}. \tag{3}$$

The angle β observed under the conditions of the Libyan Desert agrees fairly well with that obtained from formula (3). Figure 4 presents this angle at a point of the sky located on the Sun' s almucantar at $\vartheta = 90^\circ$, as a function of

Fig. 4

z, respectively on 16 and 22 XI in the forenoon (dots) and afternoon (crosses) hours. The curve referring to 22 XI, and the upper curve referring to 16 XI, represent the angle β calculated from formula (3). As can be seen, on 16 XI before noon, with a transparency coefficient $p = 0.85$, a constant difference in the orientation of the plane of vibrations from the theoretical one (about 2°) is preserved. After noon, with $p = 0.89$, the angle β agrees with the theoretical value within the limits of error.

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Note: Figure translations are in progress. See original paper for figures.