EFFECT OF OZONE ON THE TOTAL SKY AND GLOBAL RADIATION RECEIVED ON A HORIZONTAL SURFACE

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Deirmendjian and Sekera (1954) computed the total sky radiation (H) and the total global radiation (G) received by a horizontal surface, taking into consideration all the orders of scattering and reflection by ground according to Lambert's law. They assumed a plane-parallel infinite atmosphere of finite optical thickness, scattering according to Rayleigh's law. For the energy distribution in the solar spectrum outside the earth's atmosphere, Nicolet's data were adopted. The effect of absorption of solar radiation due to the atmospheric ozone was not taken into account.

Recently, Liljequist (1956) obtained a number of reliable measurements of total sky radiation (H) for different atmospheric turbidity and positions of the sun. The place of observation was Maudheim (71° 3' S, 10° 56' W) in the Antarctic. The theoretical

\[ P(u, \beta) \]

Fig. 1. Variation of the spectral distribution of sky radiation for two different zenith distances of the sun. Albedo = 0. The shaded areas give the effect of placing 0.5 cm of ozone on the top of the atmosphere.

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values given by Deirmendjian and Sekera for an albedo of 0.80 fit the observed curve for turbidity factor 0.015, while they are higher by about 10 per cent for the curve observed for a pure atmosphere. Liljequist attributes this difference to the instrumental error or to a different value of mean effective albedo. However, since the total sky radiation \( (H) \) has a spectral distribution which can be definitely modified by the three regions of ozone absorption in ultraviolet and is visible (fig. 1), it was considered worthwhile to correct the values of \( H \) and \( G \) for ozone absorption. The solution of the problem of the radiative transfer, taking into consideration the actual distribution of atmospheric ozone, is quite complicated. Therefore, as the first approximation, the total ozone of the entire atmosphere was placed on the top of the atmosphere. This would reduce the incoming direct solar radiation only.

The total sky radiation \( (H) \) is given by

\[
H = \int_{\lambda_1}^{\lambda_2} H_\lambda C_\lambda d\lambda,
\]

where \( H_\lambda \) = specific intensity of the diffused sky radiation at wavelength \( \lambda \), and \( C_\lambda \) = intensity of solar radiation at \( \lambda \). The integral is replaced by a series summation of 100 \( \lambda \) steps and limits of summation are between 2900 to 40,000 \( \AA \).

Considering \( x \) cm of ozone on the top, \( C_\lambda \) would be reduced by a factor \( 10^{-(\alpha x)/\mu_\lambda} \) where \( \alpha \) = the absorption coefficient for one cm of ozone at N.T.P. and \( \mu_\lambda = \cos \theta_0 \), \( \theta_0 \) being the zenith distance of the sun. As the values of \( \alpha \) show a large variation with \( \lambda \), mean values of \( 10^{-(\alpha x)/\mu_\lambda} \) were computed for different values of \( x \) and \( \mu_\lambda \) for each 100 \( \lambda \) band. The values of \( \alpha \) given by Vigroux (1953) for the absorption by ozone at \(-30^\circ\) were taken. Modified values of \( H \) for two different ozone amounts and five different positions of the sun are presented in table 1, along with the observed polar region is generally estimated between 0.30 and 0.40 cm. The gradual difference between the two sets for low angles of the sun can be due to either one or both of the following reasons:

1. Sphericity of the earth’s atmosphere.
2. Error involved in placing ozone on the top of the atmosphere.

Table 2. Total sky radiation \( (H) \) and total global radiation \( (G) \) in ly per min as a function of albedo, ozone, and \( \mu_\lambda \).

<table>
<thead>
<tr>
<th>( \mu_\lambda )</th>
<th>Albedo = 0.00</th>
<th>Albedo = 0.80</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>0.60</td>
<td>1.117</td>
<td>1.101</td>
</tr>
<tr>
<td>0.40</td>
<td>0.726</td>
<td>0.712</td>
</tr>
<tr>
<td>0.20</td>
<td>0.342</td>
<td>0.331</td>
</tr>
<tr>
<td>0.10</td>
<td>0.159</td>
<td>0.150</td>
</tr>
<tr>
<td>0.04</td>
<td>0.058</td>
<td>0.052</td>
</tr>
</tbody>
</table>

The effect of the total ozone amount of 0.5 cm, placed on the top of the atmosphere, on the spectral distribution of the sky radiation can be appreciated from fig. 1. Two sets of curves represent the distribution of sky radiation for two zenith distances of the sun, corresponding to \( \mu_\lambda = 0.10 \) and 0.60, respectively. The absorption in the Hartley and Huggins band reduces considerably the sky radiation in the ultraviolet, while the absorption in the Chappuis band changes the spectral distribution of the sky radiation by a considerable amount only for a low sun elevation.

Consideration of the ozone absorption, in the above first approximation, brings the theoretical values of the sky radiation to a remarkable agreement with the values measured by Liljequist in the Antarctic under a very low atmospheric turbidity. This agreement, among others, indicates the superiority of the application of Chandrasekhar’s theory on the problems of light scattering in the atmosphere.

REFERENCES

