CORRESPONDENCE AND NOTES.

551.521.3 : 551.593.54

NEW CALCULATIONS OF THE LINKE TURBIDITY COEFFICIENT

BY D. V. HOYT

Although the Linke turbidity factor has been used as a measure of atmospheric turbidity by many authors (e.g. Heidel 1972) the coefficients $P$ (defined below) generally used for its determination have not been calculated since 1930. The defining equation for the Linke turbidity factor is

$$I = \frac{I_0}{S} \exp \left( - T \tilde{a}(m) \cdot m \right)$$

where $I_0$ is the total extraterrestrial solar flux; $S$ is the reduction factor to obtain the mean solar distance; $m$ is the air mass; $\tilde{a}(m)$ is the mean extinction coefficient for a dry clean Rayleigh atmosphere, weighted for distribution of transmitted spectral irradiance; and $T$ is the Linke turbidity factor. Physically, $T$ gives the number of Rayleigh atmospheres needed to account for the observed total irradiance. $T$ therefore is always greater than one. Its value depends not only on the total aerosol content of the atmosphere (i.e. turbidity) but also on the ozone and water vapour content of the atmosphere. As such it only partially reflects what the aerosol variations are.

Eq. (1) may be written, solving for $T$, as

$$T = P(m) \left( \log I_0 - \log I - \log S \right)$$

where $P(m) = (m \times \tilde{a}(m) \times \log e)^{-1}$, is the Linke turbidity coefficient.

Previous calculations of $P(m)$ have been done by Linke (1922) and by Feussner and Dubois (1930). The latter authors' values for $P(m)$ are quoted in the IGY Manual (1956) and are the most widely used values for $P(m)$. The values determined by Feussner and Dubois were calculated semi-empirically using observed values of the solar spectral irradiance given by Fowle (1915), Abbot (1927), and the Smithsonian Misc. Coll. (1927).

Since the knowledge of the solar spectral irradiance has improved over the last forty years, it was felt the recalculations of the Linke turbidity coefficients was in order. For the extraterrestrial solar irradiance the distributions given by Thekaekara (1972) and by Johnson (1954) were used. Rayleigh optical depths as a function of wave-length were taken from Elsnerman (1968). Also, using Thekaekara's spectrum, 0-30cm of ozone was added to the dry Rayleigh atmosphere in order to see what effect it had on the values of the total irradiance $I$ and hence $P(m)$. The spectral distributions were calculated from 2900Å to 40,000Å, and the values of the total irradiance are given in Table 1 for comparison with Linke (1922) and Feussner and Dubois (1930). Table 2 gives a similar comparison for the values of $P(m)$.

As can be seen from Table 1, Linke's values of the total irradiance most closely match those calculated using Thekaekara's solar spectrum. Feussner's values are slightly less than the values calculated using Johnson's solar spectrum in all cases. When the values of the Linke turbidity coefficients are examined in Table 2, it is seen that there are major differences. The values calculated here agree best with Linke for small air mass values and with Feussner for large air mass values.

TABLE 1. VALUES OF THE TOTAL IRRADIANCE IN mw/cm$^2$ IN DRY RAYLEIGH ATMOSPHERES, CASE I USES THE THEKAEKARA SOLAR SPECTRUM, CASE II THE JOHNSON SOLAR SPECTRUM, AND CASE III THE THEKAEKARA SOLAR SPECTRUM WITH 0-30CM OF OZONE ADDED TO THE RAYLEIGH ATMOSPHERE

<table>
<thead>
<tr>
<th>Air mass</th>
<th>Linke (1922)</th>
<th>Feussner and Dubois (1930)</th>
<th>Case I</th>
<th>Case II</th>
<th>Case III</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>125.9</td>
<td>128.4</td>
<td>126.2</td>
<td>130.0</td>
<td>125.1</td>
</tr>
<tr>
<td>1.0</td>
<td>119.1</td>
<td>122.6</td>
<td>120.7</td>
<td>124.1</td>
<td>119.3</td>
</tr>
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<td>2.0</td>
<td>108.2</td>
<td>113.2</td>
<td>112.2</td>
<td>115.0</td>
<td>110.4</td>
</tr>
<tr>
<td>3.0</td>
<td>100.1</td>
<td>105.8</td>
<td>105.8</td>
<td>108.1</td>
<td>103.6</td>
</tr>
<tr>
<td>4.0</td>
<td>92.4</td>
<td>99.6</td>
<td>100.6</td>
<td>102.6</td>
<td>98.0</td>
</tr>
<tr>
<td>5.0</td>
<td>—</td>
<td>—</td>
<td>96.3</td>
<td>98.0</td>
<td>93.4</td>
</tr>
</tbody>
</table>

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The large values of \( P(m) \) by Feusser at low air mass values arise from an underestimate of the Rayleigh extinction. An artificial increase in optical depth by including 0.3cm of ozone with Thekaekara’s spectrum increases the difference from Feusser. From this one may say Feusser and Dubois underestimated what they call the UV correction, or corrections to the mean optical depth for the radiation with wavelengths less than 3420Å, which were not observed. Consequently the optical depth or Rayleigh extinction at these wavelengths was overestimated by these authors. The UV correction of 6.88% should have been in excess of 10%.

The values of \( P(m) \) using Thekaekara’s solar spectrum are the most accurate determinations now available. The uncertainty in the values is of the order of magnitude of the differences between the use of Thekaekara’s and Johnson’s solar spectra as given in Table 2. Most previous published values of the Linke turbidity factor \( T \) have overestimated its value.
CENTRAL ENGLAND TEMPERATURES: MONTHLY MEANS OF THE RADCLIFFE METEOROLOGICAL STATION, OXFORD

By C. G. Smith

I have read with interest Professor Gordon Manley's recent article (Manley 1974) which brings his valuable table of Central England mean monthly temperatures up to 1973 and extends the record further back into the 17th century. However, I am puzzled and disturbed by his comments on the reliability of the record of the Radcliffe Meteorological Station, Oxford, for which I have been personally responsible since 1950. Professor Manley suggests that the Oxford temperature record has recently become less representative, particularly since about 1960, and that this can be attributed to an 'urban effect' as Oxford has grown. He does not produce any positive evidence to support this view other than the observation that 'night minima are most affected' and a reference to some consideration of the values reported at stations such as Brize Norton, Abingdon and Sherburn 'in the adjacent countryside'.

Professor Manley quotes two of my papers and thanks me for drawing his attention 'some years ago to the tendency for the Oxford monthly means to rise relative to others'. A careful reading of my two papers quoted by Professor Manley (Smith 1968 and 1969) does not, I think, justify any such assertion. When they were written I was certainly aware of the possibility of such changes arising from an urban effect, particularly the extensions to the adjoining Radcliffe Infirmary since about 1940, but I had found no evidence for it and the implication of both papers was that this particular site was a remarkably good one for the study of long period temperature fluctuations. Any suggestion that the record had become unreliable has come from Professor Manley himself for, on two or three occasions, he has suggested this possibility to me. I have expressed my doubts to him that any such change has occurred and I have promised him that I would make a detailed examination of the record to see if this might have occurred. I had two main reasons for doubting his suggestion: firstly the remarkable internal consistency of the record; and secondly the location of the station and the character of the built-up area around it. Its location in central North Oxford...