ABSORPTION OF DIRECT SOLAR RADIATION BY WATER VAPOUR

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Summary: Radiation absorption by water vapour plays an important role in the physics of the atmosphere. The calculation of the absorbed radiation energy by water vapour requires the amount of precipitable water in the atmosphere to be known. Actinometric and aerological measurements were used to establish the relation between vapour pressure and absorbed solar radiation.

1. INTRODUCTION

From the viewpoint of investigating radiation transfer in the atmosphere, water vapour plays a major role, its amount being very variable especially in the vertical direction. The vertical distribution of water vapour is characterized, on the average, by the water vapour amount decreasing with height. In the surface layer of the atmosphere the water vapour concentration varies between 0.02 and 2.0%, in sporadic cases the values being possibly even higher [1].

Radiation absorption by water vapour plays an important role in the physics of the atmosphere. The absorbed energy changes partly into heat and produces a change of temperature in the free atmosphere. An additional part of this energy is transformed into long-wave radiation emitted into the environment.

The spectrum of radiation absorption by water vapour is very broad and is composed of absorption lines and absorption bands. The decisive portion of the absorption bands, affecting the overall absorption of solar radiation by water vapour, lies in the infrared region of the spectrum.

2. THEORETICAL ASSUMPTION

The total absorption of solar radiation by water vapour is generally described by the relation [2]:

\[ A = f(mw), \]

where \( A \) is the absorbed radiation energy [\( \text{Wm}^{-2} \)], \( m \) is the air mass, \( w \) is the precipitable water in the atmosphere [cm].

Using experimental material, Möller and Mügge, Kastrov, Mc Donald [3] suggested the following relation in the case of bright days:

\[ A = K(mw)^{0.3}, \]

where \( K = 119.9 \) according to Möller and Mügge, \( K = 108.7 \) according to Kastrov and \( K = 103.8 \) according to Mc Donald.

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3. EXPERIMENTAL RESULTS

As follows from relation (2), the calculation of the absorbed radiation energy requires the amount of precipitable water in the atmosphere to be known.

To this end, actinometric measurements were evaluated as well as aerological outputs from Vienna covering the period 1976–1980 and, for our territory, the following relation was established between the amount of precipitable water in the atmosphere $w$, the pressure of vapours $e_0$ in the meteorological cabin and altitude above sea level $Z$ at the given point [4].

$$w = 0.102 \exp \left( -1.9Z \right) e_0^{0.3}.$$  

If relation (3) is substituted into relation (2) for the most recent data of McDonald:

$$A = 52.3 m^{0.3} e_0^{0.39} \exp \left( -0.57Z \right).$$  

If the elevation of the Sun is constant at 30° ($m = 2$),

$$A = 64.5 e_0^{0.39} \exp \left( -0.57Z \right),$$

Fig. 1. The dependence of solar radiation absorbed by water vapour on vapour pressure and altitude above sea level.