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SOME FEATURES OF THE MICROCLIMATE OF A LUXURIANT TURNIP RAPE FIELD ON A CLEAR DAY

by

SEPPO HUOVILA

Department of Physics, University of Oulu.

Abstract

Diurnal variations of temperature, humidity and wind speed at different heights within and over a dense crop of turnip rape were measured by means of a thermistor psychrometer and a thermocouple anemometer. For comparison, parallel measure ments were made over a sand surface.

The general errors and instrumental errors of the measurements are discussed in the first part of the study, which is presented here. The second part, which will include a more complete analysis of the results, is to be published in the next issue of Geophysica.

1. Introduction

The material for this study was collected in June and July 1955. (Since then, the author has not had time and diligence enough to analyse the recorded data.)

The field measurements were made at Viiki Research Station, near Helsinki. This experimental station is under the supervision of the Institute of Meteorology, University of Helsinki. As the station is surrounded by a considerable area of agricultural land, it affords good opportunities for studying the microclimate of cultivated plants.

The turnip rape field to be studied was several hectares in area. For practical reasons (the cable lengths and the need to protect the plants), the measurements among the vegetation were made at distances of only about 5 metres from the border of the field. The vegetation, however, was very dense, leafy and homogeneus right up to the border. It seems very unlikely that the position of the measuring site had any effect on the results, however. During the rapid exchange in the daytime, the wind was always southerly or southwesterly, while the measuring site was on the northern side of the field. The windward side of the field was roughly a hundred metres wide, and the border of the field was to leeward of the sensitive measuring elements.

As a control, parallel measurements were made on a sand surface. At a distance of about 10 metres from the border of the field, there was a farm track covered with sand and gravel. This surface was chosen to represent conditions over a rather smooth surface. At first sight, it seems as if the measuring sites to be compared were too close to one another in view of the very different features of the microclimate above these surfaces. This may be true of the smooth surface but the author cannot believe that the conditions among the plants could have been distorted. In any event, the differences between the curves (Figs. 2—4) recorded at these two measuring sites are more likely to be too small than too great.

As every microclimatologist is aware, it is often very difficult to find a suitable time for making measurements. During days of frontal activity, strong local advection or varying cloudiness, the aperiodical changes in temperature, humidity and wind speed are often substantial. These changes may greatly exceed the periodic variation to be studied. Unless recording is continuous, the observer has to confine his activities to selected periods. Thus, during the present study, observations were made on a total of eight days and nights. Only two of these days, 27—28 June and 12—13 July, were considered by the writer to be sufficiently representative of a clear day with light or moderate winds.

The question also often arises of whether the values obtained should be presented as such, (in plotting a climatic factor against time) or as smoothed curves. The former alternative results in figures which are more or less polygonal in form, depending on the number of readings made, the response characteristics of the instruments and the fluctuations of the climatic factor to be measured. The latter alternative, on the other hand, gives us curves of a fairly smooth appearance even if there are relatively few observations. In defence of the former alternative it is often said that the polygons are »true» and the smoothed curves »artificial». Nature, however, rejects the zig-zag form as an expression of the mean course of events integrated over a sufficiently long time. Our »true» curve is therefore an expression of the combined effects of the fluctuations and the accidental errors of the measuring system.

The present author's opinion is that smoothing methods, such as those described in [1], should be more generally applied in meteorology than hitherto when results are presented in the form of a curve purporting to represent the mean course of events, provided that the effect of smoothing is not out of proportion to the original values. To present fluctuations or lines of discontinuity is, of course, an important exception.

2. *Instruments*

A. Thermistor psychrometer

Temperature and humidity values at different heights above the ground, as well as the ground temperature, were measured by means of a thermistor psychrometer with natural ventilation. The psychrometer was composed of two Stantel F thermistors. The sensitive semiconductor of these thermistors is a roughly spherical bead about 0.3 mm in diameter. It is fused under a thin glazing onto the tip of a 3.2 mm thick glass tube.

In a previous paper [3] the author has classified common errors and instrumental errors which are liable to occur in micrometeorological measurements made near the ground. To start with instrumental errors, the magnitudes of the circuit errors, the radiation error and the ventilation error in this connection have to be estimated.

The most important circuit error of small-size thermistors is the heating of the semiconductor bead due to the measuring current. As the power sensitivity of Stantel F thermistors was not accurately known to the author, a test was made in May 1960 at the Institute of Physics, University of Oulu. The power sensitivity, as a mean of three thermistors, (Fig. 1) was found to be at 25°C, when the heating power was under 5 mW:

Thermistor in water	0.24 °C/mW
» in still air	1.45 »

The maximal power through the thermistors was less than 0.02 mW during the measurements. The measuring voltage was controlled to within 0.1%. As the change of resistance versus temperature of the thermistors was of the order of 5%/°C, the accuracy of the voltage control corresponds to 0.02°C. Compared with the required accuracy of 0.1°C, these circuit errors are negligible.

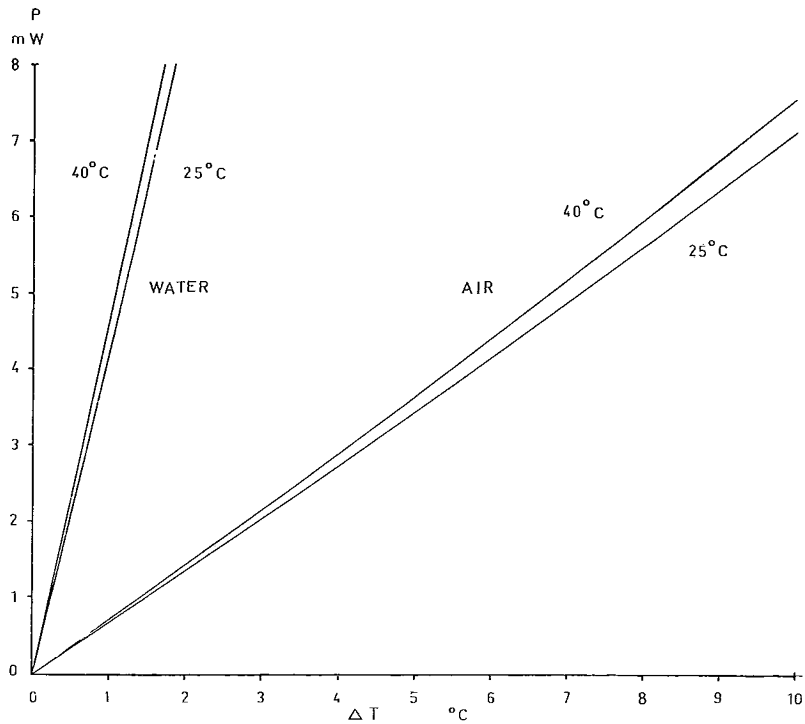


Fig. 1. Power sensitivity of Stantel F thermistors in water and in still air.

The psychrometer was provided with a convex radiation shield of aluminium sheeting to prevent direct insolation. The radiation shield could be moved according to the earth's rotation. As the radiation error of these thermistors is far less than that of ordinary screen thermometers with a mercury filling, this primitive shield at a distance of about 15 centimetres from the psychrometer was certainly able to reduce the radiation error to less than 0.1°C at all hours and in all situations. The advantage of this shield over ordinary radiation shields was that the placement in an inclined position did not disturb the vertical exchange.

If humidity measurements are made very near the ground by means of a psychrometer, the problem of ventilation error soon arises. If the psychrometer is provided with artificial ventilation, the surrounding atmospheric layers are mixed. This method cannot be used near the ground, where the vertical temperature gradient varies significantly at very short distances. Every psychrometer, however, will need a certain ventilation speed for its proper function. The psychrometer equation can be written:

$$e = E' - ap(t - t') \tag{1}$$

in which

e = vapour pressure in air
E' = saturation vapour pressure at the wet bulb temperature
a = psychrometer constant
p = atmospheric pressure
t = dry bulb temperature
t' = wet » »

The effect of ventilation on the psychrometer constant can be determined experimentally. As the ventilation speed increases, the psychrometer constant decreases until it reaches an almost steady value. For the Assmann psychrometer, the minimum speed for proper functioning is roughly 2.5 ms^{-1}.

The dependence of a Stantel F thermistor psychrometer on ventilation speed has been previously determined and reported by the author. [3] When the ventilation speed was over 0.6 ms^{-1}, the permanent value of the psychrometer constant was reached. The dependence of the psychrometer constant on the ventilation speed being known, we can now compute values of relative humidity and vapour pressure on the basis of simultaneous wind speed observations. This method was applied in the present humidity computations.

B. Thermocouple anemometer

If measurements are made very near the ground, a very sensitive anemometer is needed to record the wind speed. The friction velocity within dense vegetation is of the order of 10 per cent of the velocity in the open above the plants. At night during stable conditions very low wind speeds are also observed above a smooth surface.

To meet these difficulties, a thermocouple anemometer was constructed by the author. The sensitive element was a copper-constantan thermocouple in which one of the junctions was covered with a small, isolated coil of very thin constantan wire, the other junction being uncovered. If the former junction is heated by passing a suitable current through the coil, it will acquire a temperature somewhat higher than the

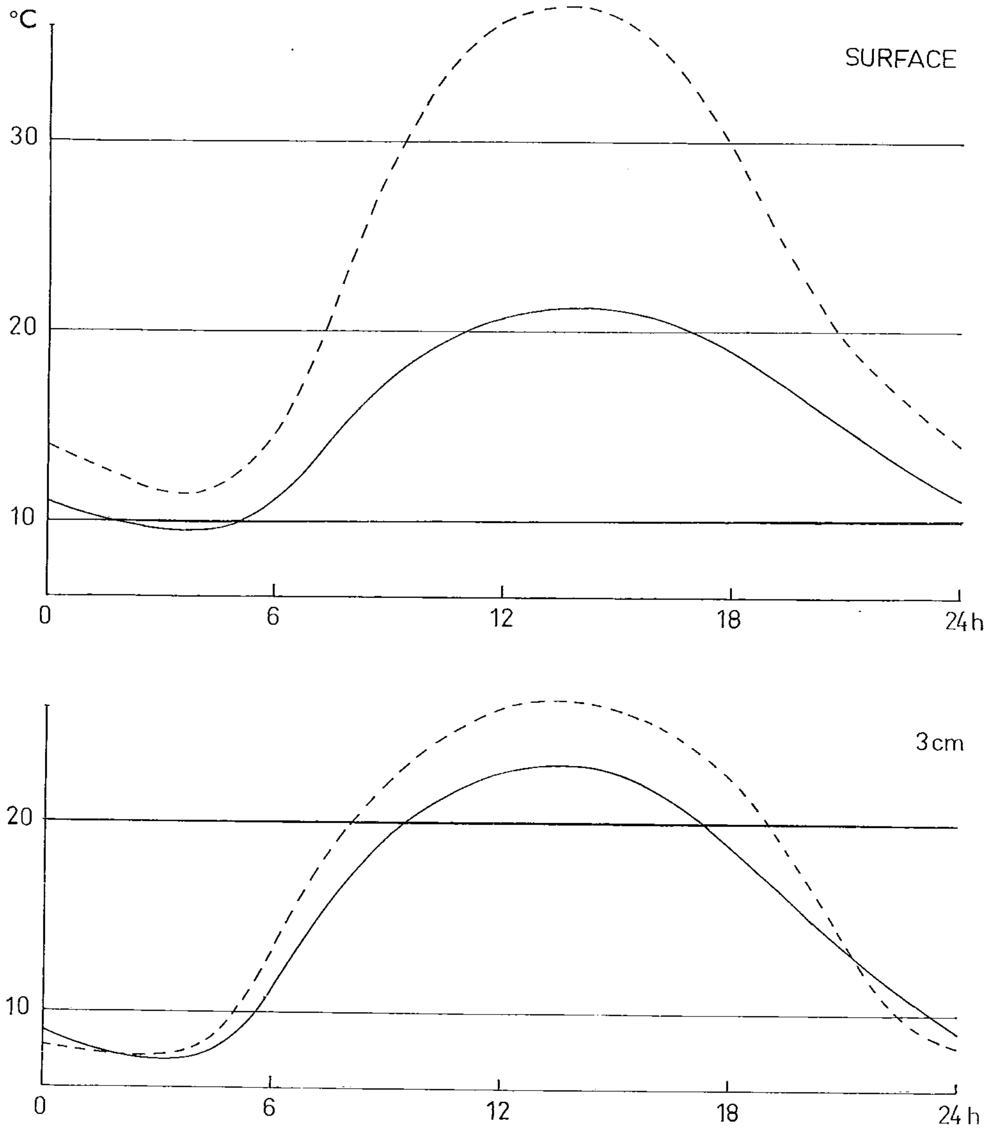
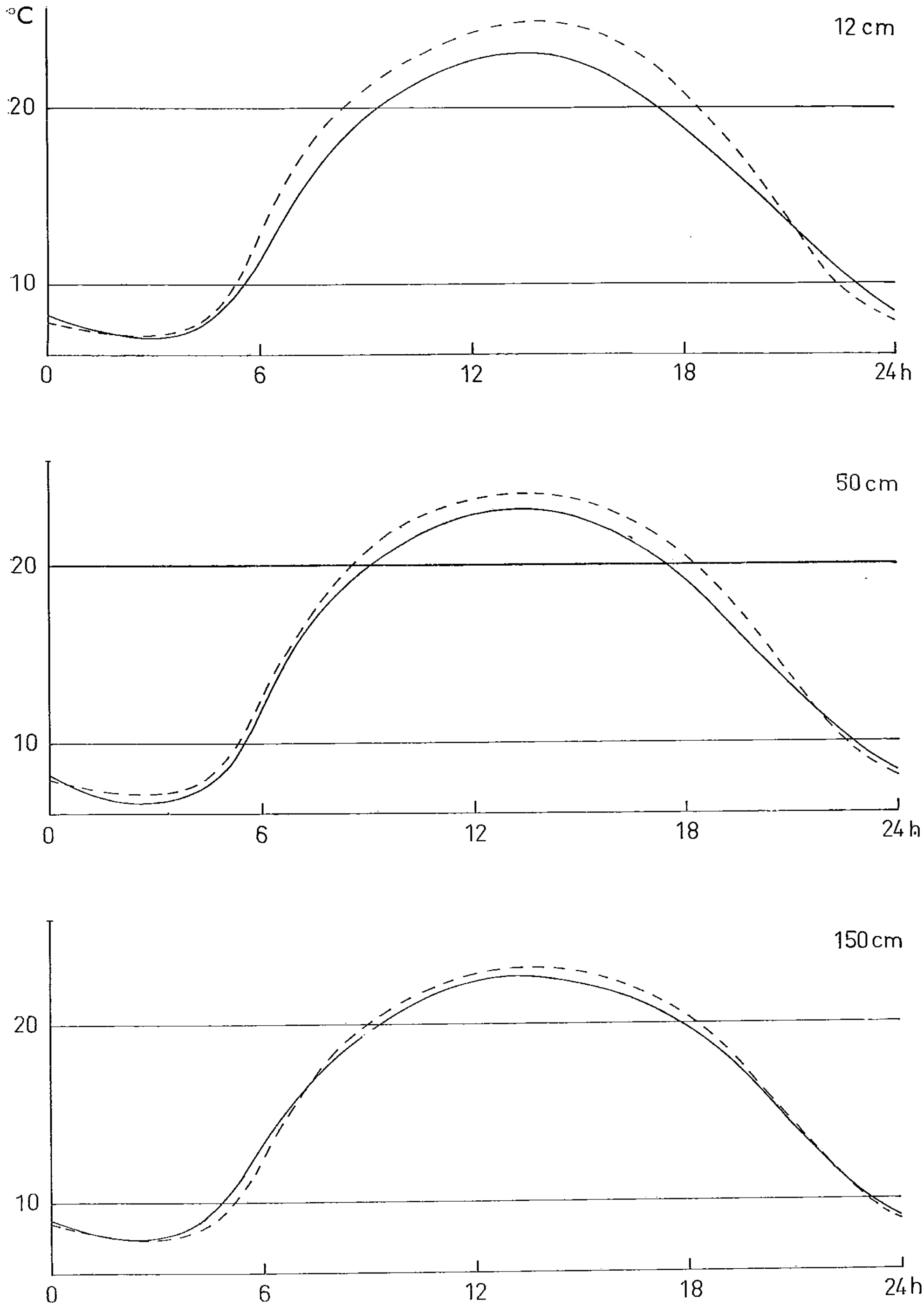


Fig. 2. Mean diurnal variation of surface temperature and air temperature at heights of 3, 12, 50 and 150 cm above soil covered by a dense crop of turnip rape of mean height of 85 cm (solid lines) and over a sand surface (dotted lines) on clear days.


°C
12 cm
20
10
0
6
12
18
24 h
50 cm
20
10
0
6
12
18
24 h
150 cm
20
10
0
6
12
18
24 h

latter junction. The temperature difference Δt depends on the prevailing wind speed, according to KING's equation:

$$\Delta t = Ri^2 (a + b\sqrt{v})^{-1} \qquad (2)$$

where

R = coil resistance
i = heating current
v = wind speed
a, b = constants, depending on temperature, wire diameter and properties of air

The coil being of constantan wire, R and i are constants during the measurements and Δt is inversely proportional to the square root of wind speed. More details of the function of this anemometer were given in a previous paper by the author. [2]

3. *General remarks on the observations*

Observations were made every two hours by means of the electric psychrometer, which could be adjusted to heights of 3, 6, 12, 25, 50, 100 and 150 cm above the ground. Vertical soundings were made beginning with the lowest height in the vegetation, then taking the top height and returning to the lowest. Double observations were thus obtained from both dry and wet bulb thermometers. First and last, the ground temperature was read by covering the dry bulb with a very thin layer of soil. The psychrometer was then moved to the control area and the procedure repeated. Throughout the procedure, marks were made to record the true time of observation. A vertical sounding took roughly 5 minutes to make. After the psychrometer soundings, wind soundings were carried out over both measuring sites at heights of 3, 12, 50 and 150 cm.

The sounding method, if not continuous, is unsuitable for a situation with large-scale temperature or wind fluctuations (of some hours' duration). Fluctuations of small and intermediate scale are largely reduced and smoothed out as a result of the up and down soundings and the fact that 3 readings at 5-second intervals were made at every position of the sonde. As was mentioned before, however, only 2 days out of 8 were suitable to represent conditions on a clear day in the opinion of the author. On the other hand, the sounding method has the advantage that all the observations are made with the same instrument. Systematic

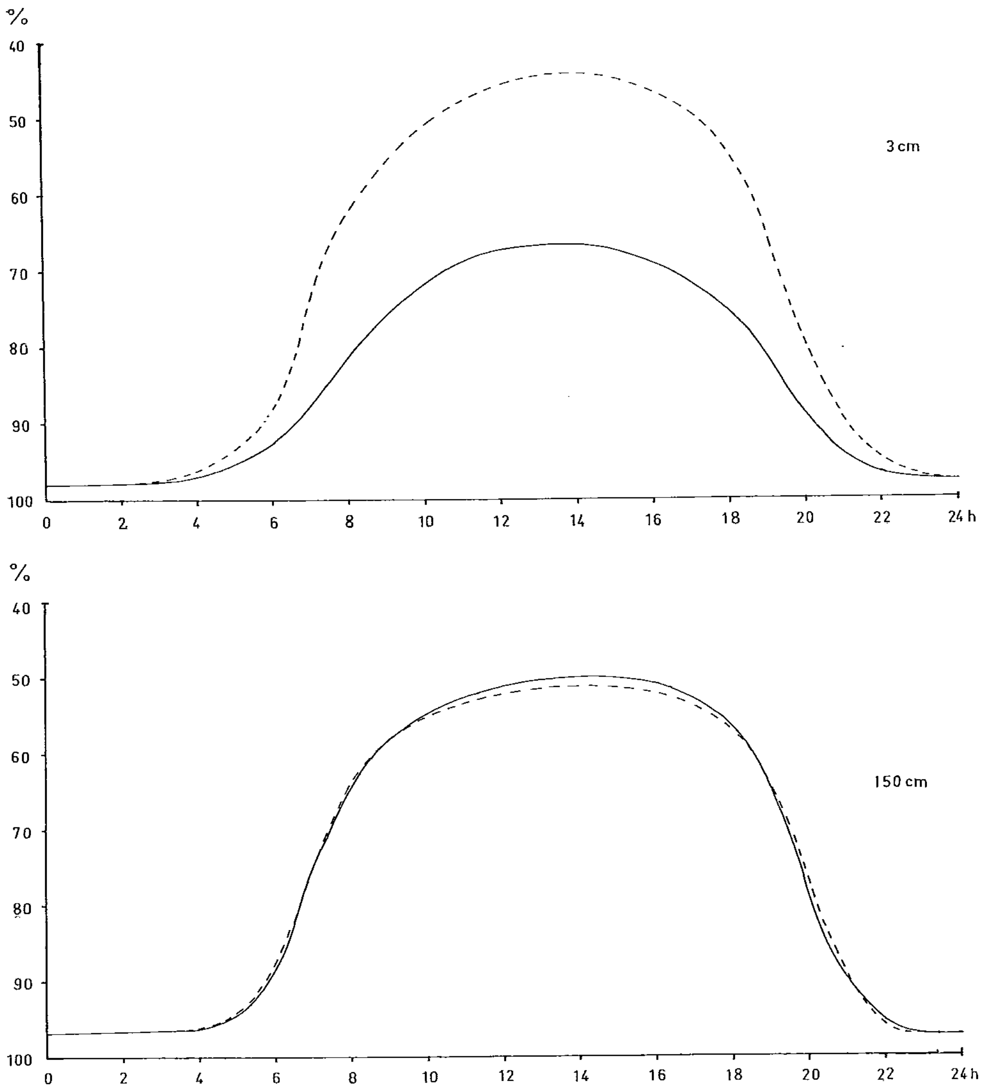


Fig. 3. Mean diurnal variation of relative humidity at heights of 3 and 150 cm above the same surfaces as in Fig. 2.

errors such as inaccuracies in the calibration and mounting of different psychrometers and anemometers are thus eliminated. The same holds good for the moistening and mounting of the wet bulb socks.

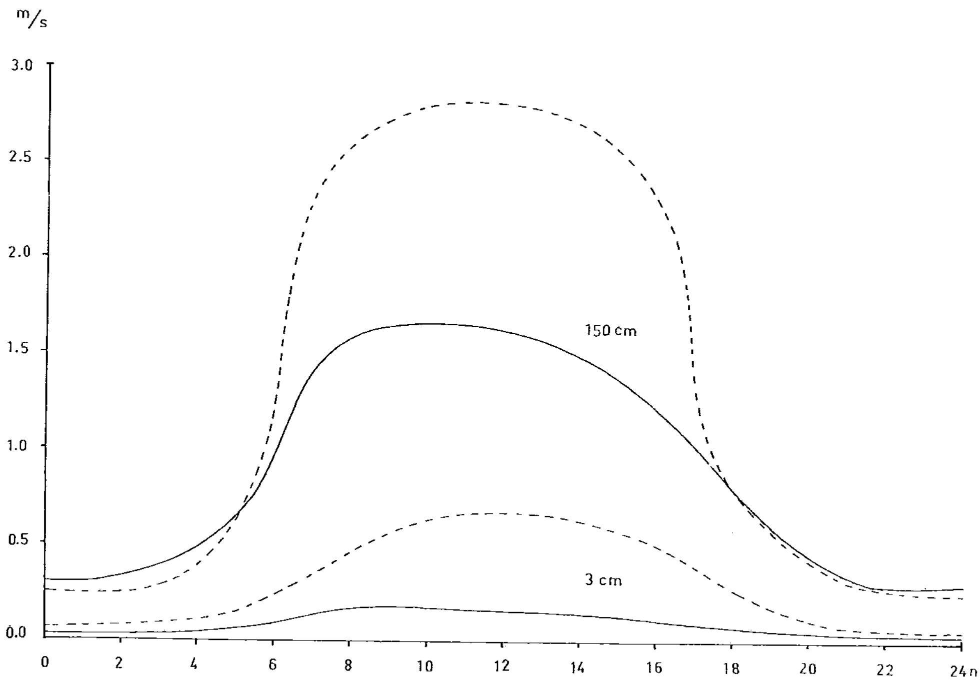


Fig. 4. Mean diurnal variation of wind speed at heights of 3 and 150 cm above the same surfaces as in Fig. 2.

As preliminary results, Figs. 2—4 are given. The method of smoothing by overlapping means has been used in the almost linear parts of the curves, while the method for smoothing out a curve of parabolic form has been applied to the smoothing of the daytime curves. A more thorough analysis with vertical profiles will be published in the next issue of Geophysica.

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