A Topoclimatic Investigation of the Region around Værløse

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Abstract

Temperature conditions in an area NW of Copenhagen based on field studies and presented on two maps to draw a picture of the topoclimate in the region. Two types of temperature distribution and some factors influencing them are studied, i. e. weather situation, relief, and ground surface.

In autumn 1961 a group of students at the Geographical Institute of the University of Copenhagen started a topoclimatic investigation at Værløse, a suburb to the northwest of Copenhagen. This region was chosen because a town plan of Værløse was just under preparation, and geographers had contributed with an analysis of the physical geography to which a topoclimatic investigation was a natural supplement. For practical reasons the investigation was limited to the temperature conditions.

The work was carried out in close collaboration with *Kr. M. Jensen*, associate professor at the Geographical Institute, and had the character of a course for students majoring in geography. The purpose was 1) to become familiar with measuring instruments and methods used in topoclimatology, 2) by means of collected data to illustrate the regularities within topoclimatology and 3) to attempt to draw a picture of the topoclimate in the region around Værløse. In the following a selection of collected measurements is presented.

Measuring programme

Topoclimatology is concerned with the dependence of the climate on topographical conditions. A survey of the topography of Værløse is shown in fig. 13, as well as on plate I and II, while fig. 1 gives

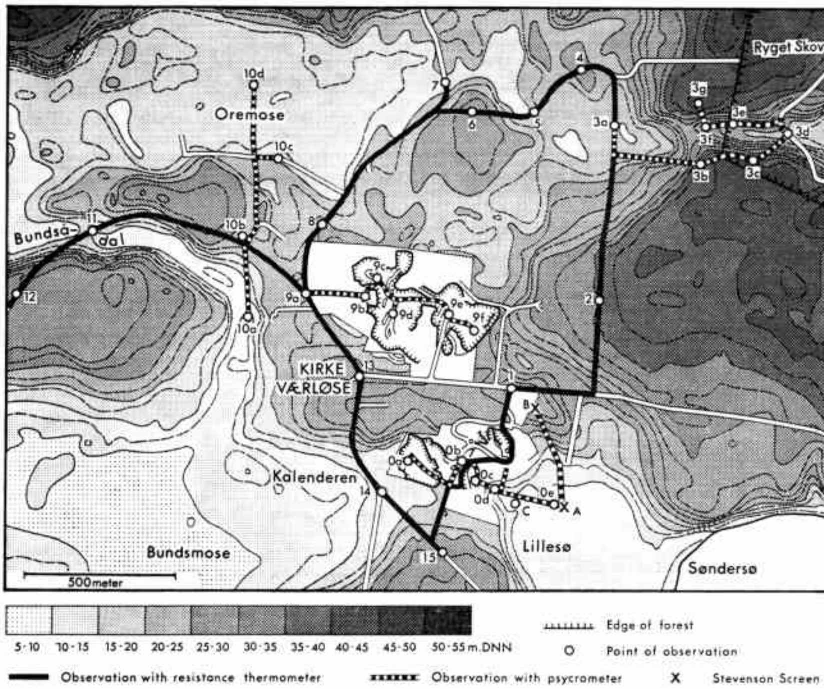

Fig. 1. Kurveplan over området omkring Kirke Værløse med markering af engelske hytter og målenet.

Fig. 1. Contour map of the region around Kirke Værløse with location of Stevenson Screens and observation routes.

a more detailed picture of the relief in the region around Kirke Værløse, the place where most of the registrations were made.

As mentioned the programme had several purposes, among others to illustrate the application of various instruments such as thermographs, Assmann Psychrometers, and a resistance thermometer with a mounted galvanometer. At the fixed stations marked A and B (fig. 1) two Stevenson screens with thermographs were exposed from December 1961 to April 1963; the screens were placed 50 cm above the grass for registration of the temperature in the lower part of the profiles that were to be investigated (between 10 and 150 cm above the ground). The difference in level of the two screens was abt. 20 m; screen A was placed in the bottom of the valley west of lake Søndersø abt. 14 m M.S.L. and screen B on a ridge 330 m further north abt. 34 m M.S.L. The thermographs were fitted with weekly clocks and the observers inspected them alternately; the registrations were controlled by an Assmann psychrometer.

The thermographs covered a temperature range of about 40° C

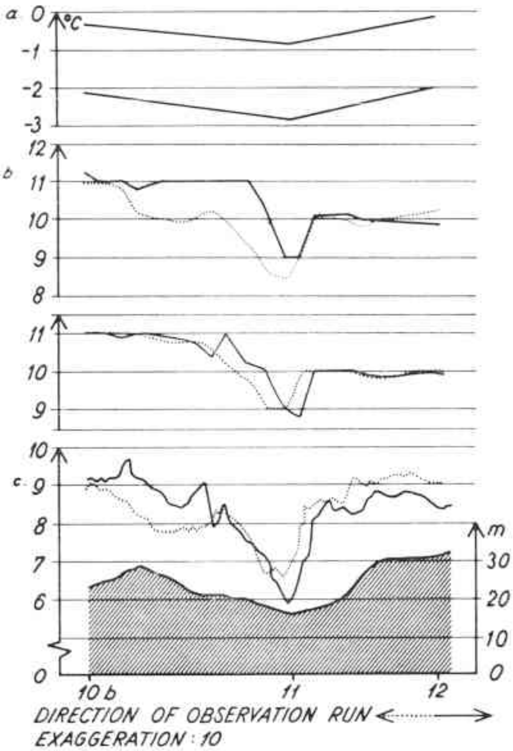

Fig. 2. Temperaturkurver fra målekørsler på tværs af dalen mellem station 10 b og 12. Nederst er vist terrænprofilen og derover de fire sæt kurver, optegnet på grundlag af observationer med forskellig tæthed — se iøvrigt teksten.

Fig. 2. Temperature graphs from observation drives across the valley between station 10 b and 12. At bottom the relief profile and above it the four set of temperature profiles drawn on basis of observations with varying density — cf. text.

and were adjusted according to season of the year. As control measures a thermograph with daily clock was placed in the two screens for a certain period in order to give a more detailed picture of the temperature course. It was found difficult to make the two thermographs work in a uniform way, and during a period it was ascertained that one of the graph drawings gave more detailed records of minor variations in temperature. Control measurements proved that this must be due to differences in sensitivity of the instruments and not to different temperature course at the stations as it was first assumed. In autumn 1962 both thermographs suddenly gave some very deranged graphs which were impossible to interpret. Later, however, traces of mice revealed the reason why, and the thermographs were placed in small wire netting boxes.

The two screens were starting points for the regional temperature measurements on the routes indicated in fig. 1. The observations were made partly with a resistance thermometer on the long route marked by the figures 0-15, partly with Assmann psychrometers on the additional routes (marked by letters) starting from the points

0, 3, 9, and 10. With psychrometers the temperature was registered at four levels in each point: 10, 50, 100, and 150 cm above the ground. The routes could be walked through in an hour's time, and measurements were made at every second point on the walk out and at the remaining on the walk back in order to control possible regional temperature changes during the measuring period.

The observations with resistance thermometer were made from a car. A stick with a platinum wire mounted on a transverse stick at the end was held outside the car abt. 50 cm above the ground. These drives involved three persons: one drove the car and observed fixed points on the route, another read the records and the third took notes. Normally, the values could be read with an accuracy of one fifth of a degree, which was corresponding to the thermometer scale of the Assmann psychrometer; on gravel roads, however, the readings were extremely difficult.

Fig. 2 shows a series of measurements made in different ways in order to demonstrate the value of many or few observation points in a region with differences in level of only 10-15 m. By the first method employed records were only made at the points 10 b, 11, and 12. At each point the car was stopped for a few minutes and the platinum wire was ventilated by moving the stick so the transverse stick was made swinging. The readings from one of these drives are shown in fig. 2 a.

The second method was that a number of ranging poles was set between the two terminal points and the position of the poles entered on the route map. Then the route was driven through, and the temperature read by each pole passed. The result is shown in fig. 2 b.

Thirdly, the reading was made with an interval of 2 seconds; fig. 2 c shows the result. Naturally, this method gives a more detailed picture than the two first mentioned. In the second and third case the route was driven through in both directions at a speed of abt. 20-25 km/hr., and the values found are indicated in the figures by a continuous line for the drive out and a broken line for the way back. It is seen that the maxima and minima values found out and back do not coincide, the values being dragged somewhat into the direction of driving. Undoubtedly, this is due to the thermometer's lag.

As it appears from fig. 2 a dense measuring net is necessary, if the very fluctuating temperature pattern is to be taken down; but it would be a difficult task here to discuss the specific jumps of the temperature graphs and point at the many local surface variations influencing the pattern; some of them, however, will be discussed later. The general impression is clear enough with relatively high temperatures on the ridges and accumulation of cold air masses in the basins.

The total measuring programme will be seen from the survey below and from fig. 4. The observations have mainly been made in the evening and by night, where the differences in temperature from ridges to valleys should be the greatest, and disturbances, f. inst. from other vehicles on the roads, as few as possible.

Observation programme:

March 16, 1962 16.45 h. – 23.10 h.

March 19, 1962 17.05 h. – 23.10 h.
Measurements with Assmann psychrometers on the routes starting from the points 0, 3, 9, and 10 and with resistance thermometer 50 cm above the ground at the points 0–15 (fig. 1). Both nights a thermograph with daily clock was exposed at point A.

September 20, 1962 20.00 h – 22.00 h.
Measurements with resistance thermometer 50 cm above the ground at 41 points on route 7–8–9a–10b–12 and readings with an interval of two seconds on the stretch between point 10b and 12 (cf. fig. 2).

December 1, 1962 17.55 h. – 22.15 h.
Measurements with Assmann psychrometers on route 0 and A-B; further above different types of surface around point C (fig. 1).

March 14, 1963 17.30 h. – 20.10 h.

March 22, 1963 17.30 h. – 20.35 h.

March 23, 1963 5.35 h. – 8.25 h. and 15.00 h. – 19.00 h.
Measurements all three days with Assmann psychrometers above different surfaces around point A and B.

April 7–8, 1963 23.50 h. – 0.10 h.
Measurements with resistance thermometer 2 m above the ground with readings every two seconds between points 10b and 12. Additionally, measurements were taken on a route centre of Copenhagen – Kirke Værløse 22.15 h. – 23.45 h.

April 8, 1963 1.40 h. – 2.30 h.
Measurements with Assmann psychrometers on transverse route at Od.

March 7–8, 1964 21.20 h. – 0.55 h.
Measurements with resistance thermometer 2 m above the ground; readings were made every two seconds on a route grid covering the greater part of the parish of Værløse (pl. I and II). A thermograph with daily clock functioned at point B between 21.10 h. – 24.00 h.

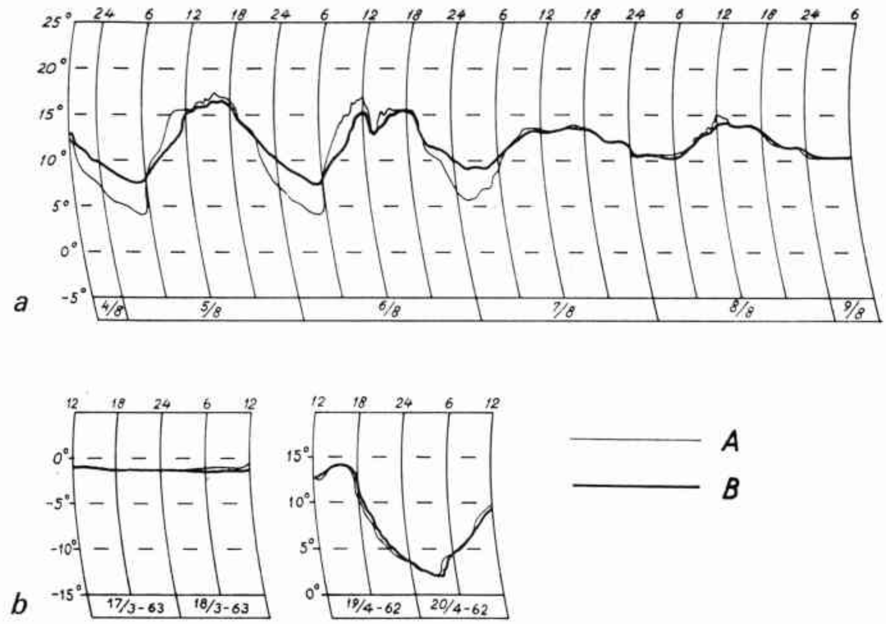

Fig. 3. Temperaturkurver optegnet af termograferne i de engelske hytter A og B.

Fig. 3. Temperatures registered by the thermographs in the Stevenson Screens A and B.

Types of temperature distribution

The measurements made have clearly shown the existence of two different types of temperature distribution. Type I is characterized by:

a) different diurnal amplitude at the measuring points; mostly in connection with great diurnal amplitude.

b) difference in temperature between points at different ground levels.

c) difference in temperature between points at different levels above the ground.

d) difference in temperature between points above different surfaces.

Type II is characterized by:

a) identical diurnal amplitude at all measuring points; the amplitude can variate from 0 to high values.

b–c–d) identical temperature at alle measuring points though ground level, level above surface and character of surface are different.

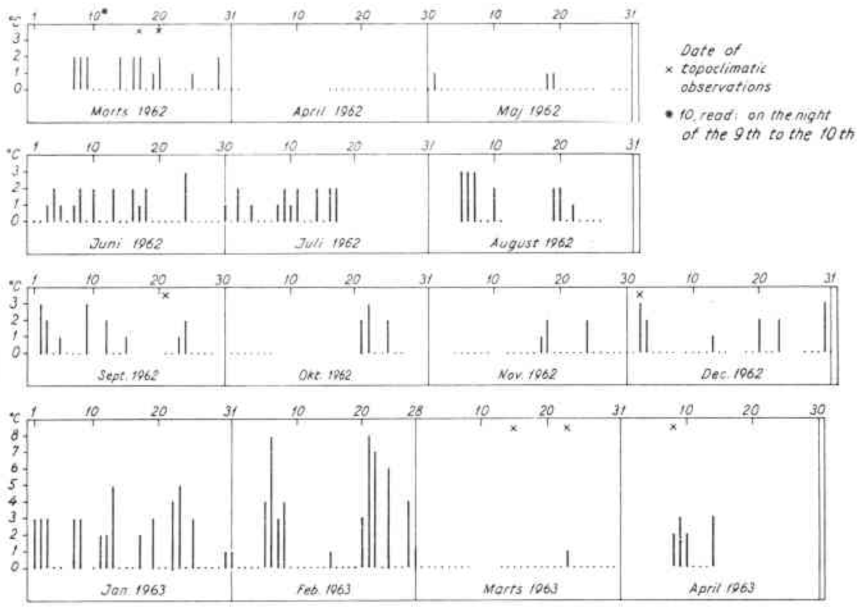

Fig. 4. De maximale natlige temperaturforskelle mellem de engelske hytter A og B opgivet i hele grader. En temperaturforskel på 0° er markeret ved en prik på nullinien. Manglende markering betyder, at brugbare måleresultater savnes fra det pågældende døgn. Kryds markerer de døgn, hvor yderligere topoklimatiske målinger er foretaget.

Fig. 4. The maximum nightly temperature differences between Stevenson Screen A and B shown in whole degrees. A dot on the zero line indicates a temperature difference of 0 degrees. When signs are missing usable observations have not been available. Crosses indicate dates where further topoclimatological observations were made.

The thermographs exposed in the Stevenson screens (fig. 1) register the conditions mentioned under a and b. The two thermograph curves from the period August 4 to 9, 1962 have both been reproduced in fig. 3a. The temperature distribution is of type I during the first 3 days and of type II the last two days. Fig. 3 b shows the variation in diurnal amplitude within type II. In both cases the curves made by the thermographs are identical, but the diurnal amplitude is significantly different.

In order to investigate the frequency of the two types the thermograph curves were studied for the 305 days for which reliable records were available. It appeared that for 92 days the temperature was at least one degree lower at the valley station A than the temperature at the top station B at some time during the night. This means that a temperature distribution of type I is observed for 92 days, i.e. for 30 % of total number of days.

The maximum difference in temperature observed between points

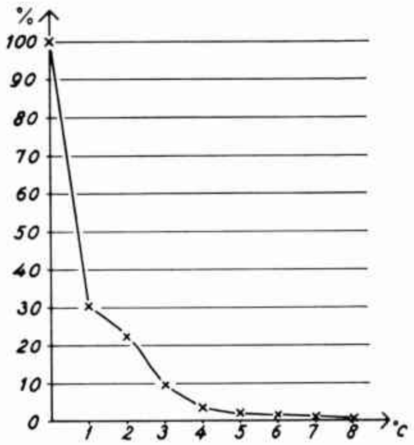

Fig. 5. Kurve visende hyppigheden af de maximale natlige temperaturforskelle mellem de engelske hytter A og B.

Fig. 5. Graph showing the frequency of the max. nightly temperature difference between Stevenson Screen A and B.

A and B is 8° C. In consideration of the fact that the measuring points lie at the same level (50 cm) above identical surfaces (grass), and that the horizontal and vertical distances between the two points only amount to 330 m and 20 m respectively, a difference in temperature of 8° C may seem surprisingly great. It should be added, however, that it was only recorded twice: on February 6, 1963, ÷ 11° C was recorded at top station B at 01 h., while the thermograph recorded ÷ 19° C at the valley station A. On February 21, 1963, ÷ 16° C was recorded at the top station against ÷ 24° C at the valley station.

Fig. 4 shows the maximum nightly temperature difference between the two measuring stations for all 305 days expressed in whole degrees; simultaneously the seasonal variation of the two temperature distribution types is indicated. Both types are seen all the year round, though the extreme cases of type I with the great temperature differences seem to be restricted to the winter months. The frequency of the measured temperature differences is indicated in fig. 5; it is obvious that the small temperature differences from 0 to 3 degrees dominate (90 %), whereas greater differences of more than 3 degrees amount only to 10 %. Temperature differences of 5 degrees and more account for only 2 %.

It is evident that periods with great temperature variations are especially well suited for topoclimatological investigations, and as often as possible observations were made during such periods, which we tried to foresee looking at their dependence on the weather situation (see below). From fig. 4 it is obvious, however, that we only succeeded to a small extent. This means that the character of the following results is not so pronounced as would have been

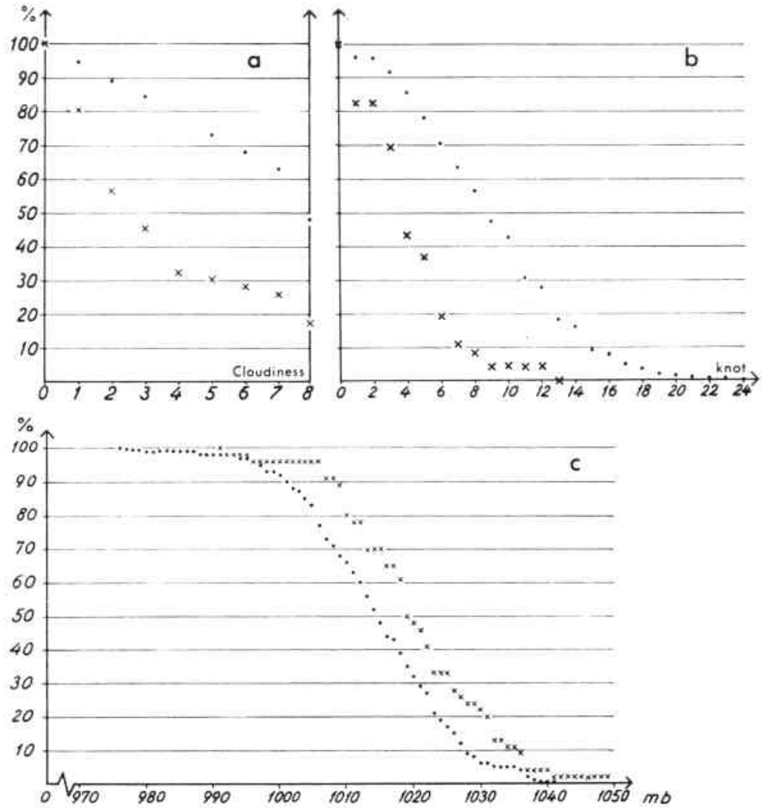

Fig. 6. Kurver visende sammenhængen mellem temperaturfordelingstypernes forekomst og a) skydækket, b) vindstyrken, c) lufttrykket. Krydser angiver type I, prikker type II.

Fig. 6. Graphs showing the interaction between a) cloud cover, b) wind speed, c) air pressure, and the occurrence of the two types of temperature distribution. Type I shown by crosses, type II by dots.

possible under ideal conditions. On the other hand the results do not show extreme and unusual values, but reflect phenomena occurring every year and at all seasons.

The region around Værløse is well suited for an investigation of the relation between the two temperature distribution types and the weather situation, as it is possible to benefit from the observations made at the meteorological station at Værløse and published by the Danish Meteorological Institute in daily weather reports. The material thus available includes reports on wind, cloudiness, air pressure, and temperature but only observed at 7 h. This means that fig. 4's distribution of type I and II can only be directly related to the weather reports, if the nightly temperature distribution type entered in fig. 4 still exists at 7 h. Fig. 3 a shows that type I was recorded the first three nights, but the difference in temperature between the measuring stations is only maintained up to 7 h. for the first two nights, while for the third one type II was observed at 7 h. For 46 of the 92 nights with a recorded temperature distribution of type I this type was maintained after 7 h. Thus, at 7 h. the temperature distribution was of type I for 46 days and of type II for 259 days.

In fig. 6 the occurrence of the two types is related to cloudiness, wind speed, and air pressure. Fig. 6 a shows that type I occurs more often than type II when the sky is nearly cloud-free. About two thirds of the cases of type I occur under a cloud ceiling covering less than half of the sky, whereas about half of the cases of type II occurs under total cloudiness. Type I may also be found under total cloudiness, while type II may prevail when the sky is nearly cloud-free. In the first case the explanation could be a total but very thin cloud cover; however, this is contradicted by the observations mentioned in the following paragraph. In the second case the most probable explanation is strong wind. Thus fig. 6 b shows that 90 % of the cases of type II occur at wind speeds of 7 knots or more. The occurrence of type II, when wind speed is low, should be related to the cloud cover, while the cases observed of type I by wind speeds as high as 23 knots might be ascribed to local sheltering effects at station A. From fig. 6 c it appears that type I occurs more frequently in connection with high air pressure than type II, which is due to the fact that high air pressure often gives calm and cloudless weather. It also appears that occurrence of type I is not restricted to high pressure situations and vice versa that high pressure does not always cause a temperature distribution of type I to develop. It may therefore be concluded that there is no simple relation between air pressure and type of temperature distribution, which was not to be expected either, if only for the reason that high air pressure does not always mean calm and slight cloud cover, but sometimes gives wind or fog. Further, passage of the central part of a low pressure might give a period with a cloudless sky and weak wind.

The thermograph curves for 305 days at station A and B provide a good material to illustrate the temperature course during 24 hours at the two locations. Because of some imperfection the material has not been statistically worked up, but some characteristic features of days with type I are discussed in the following:

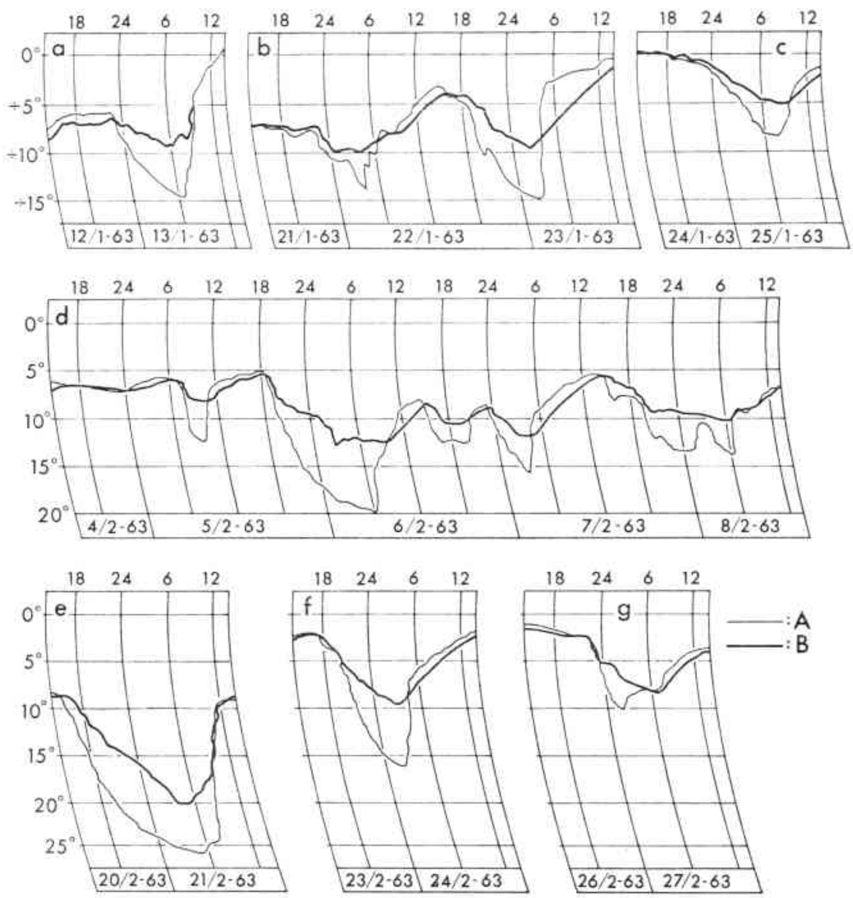

Fig. 7. Temperaturkurver optegnet af termograferne i de engelske hytter A og B.
Fig. 7. Temperatures as registered by the thermographs in the Stevenson Screens A and B.

From fig. 3 a it appears that the first two days and nights have a temperature distribution of type I, while the situation changes in the course of the third day. The temperature course reflects the diurnal radiation rhythm and is almost identical for the first two days and nights; minimum temperature is reached simultaneously at A and B about 5 h., approximately half an hour after sunrise at 4.25. A little later the temperature rises, most at the valley station, which before noon hereby obtains a day temperature considerably higher than that registered on the plateau. A temperature course of this type is seen from March to September on days with radiation weather. The nightly temperature difference between station A and B is 1-2 degrees, max. 3 degrees (fig. 4). A diurnal rhythm of this kind has not the same frequent occurrence for winter nights with great temperature differences, at least minimum seldom occurs at sunrise. Fig. 7 shows all days and nights with a nightly temperature difference of 4 degrees and more between station A and B. For these 11 days and nights temperature minimum was observed three times before 3 h., six times between 3 and 6 h. in the morning and only twice about or after sunrise. For all 11 days and nights a considerable rise in temperature was registered just after minimum temperature was reached, for example a rise from ÷ 15° C to ÷ 3° C between 3 and 5 h. in the morning on January 23 (fig. 7 b). At station B the rise in temperature started at the same time but developed slowly so that the valley station had a higher temperature than the plateau from a little before 4 h. until almost 18 h. the following afternoon, a total of 14 hours.

Unfortunately, we have not had the luck in situ to observe the processes that determine this early, significant rise in temperature. Neither changed radiation conditions in the upper air, cloudiness nor wind can explain the phenomenon. One possible explanation is that the rise in temperature is caused by formation of fog in the valley. The condensation of water-vapour developes great quantities of heat, and at the same time the fog has an isolating effect impeding the outgoing radiation that might have caused a further fall in temperature. Also white frost may be an influencing factor. Reliable humidity measurements and direct observations would throw light on these problems.

Factors influencing the temperature distribution

It can be difficult to explain the various factors influencing temperature conditions in an investigation of this kind, where observations are not carried out permanently; as already stated the ideal situations are difficult to foresee and the field work is consequently not always done at the most favourable time. It was obtained, however, to demonstrate the influence of cloud cover, of relief and of vegetated and barren surfaces on temperature profiles.

In fig. 8 is reproduced the temperature distribution at a level of 50 cm above ground surface at different times of the night on March 16, 1962, on route 0 and 3 respectively to show the influence of *clouds*. The first part of the period is characterized by relatively high temperature differences between the single points on both routes. The low temperatures are registered in the lower parts of the terrain, where the air is up to 4 degrees colder than at the

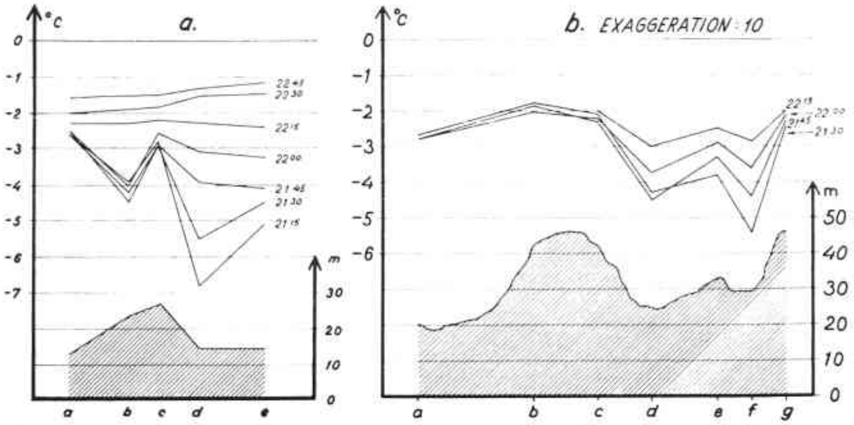

Fig. 8. Temperaturer i 50 cm-niveauet til forskellige tidspunkter d. 16/3-1962 på rute 0 (a) og rute 3 (b). Terrænprofilen er skraveret, og bogstaverne nederst på figuren angiver målepunkter på ruterne.

Fig. 8. Temperatures at the 50 cm level on route 0 (a) and route 3 (b) at different times 16/3-62. The relief profile is hatched and the letters at bottom indicate observation points on the routes.

measuring points above the higher areas (cf. point c and d in fig. 8 a). During the measuring period the temperature rises at all points, and at 22.15 h. the rise amounts to 2-4 degrees in the bottom of the valleys, but elsewhere only to 0,5-1 degree. Accordingly, the differences in temperature are eliminated and after 22.15 h. the rise in temperature is almost identical at all measuring points on route 0.

A detailed thermograph curve was plotted at station A the same night (fig. 9), from which it also appears that the temperature rises very quickly by abt. 3 degrees around 22.00 h. This rise – occurring a little later than the rise for profiles in open air – is at 22.45 h. succeeded by a fall, which was unforeseeable and therefore not included in the other observations. Just around 21.30 – 22.00 h. it was observed that a thin and rather high cloud ceiling had formed and covered the whole sky; simultaneously a very light haze was observed.

The temperature development might be explained in the following way: in cloudless nights a heavy outgoing radiation occurs from the earth surface, which is therefore cooled down. The air masses close to the earth give off heat to the earth's surface by conduction and on account of the increased specific gravity the cold air from the higher parts of the terrain will sink and develop frost hollows. These are, as shown in fig. 8, developed around 21.15 h. If a cloud cover is formed the effective outgoing radiation will decrease be-

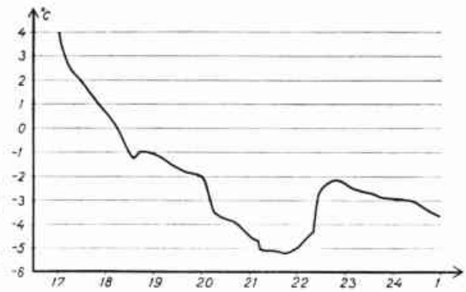

Fig. 9. Termografkurve fra punkt A kl. 17.00 d. 16/3 til 01.00 d. 17/3-1962.

Fig. 9. Temperatures registered by the thermograph at point A March 16, 1962, at 17.00 h. to March 17 at 01.00 h.

cause of counter radiation from the clouds, and the restrained outgoing radiation reduces the speed at which the air masses close to the earth will be cooled down. As a consequence the supply of cold air into the hollows will cease and this might be the cause of the elimination of the frost hollows. Further, the amount of heat released during the formation of the haze might have contributed to the increase in temperature. The formation of haze is probably a result of the strong cooling of the air masses close to the earth that occurred before the cloud cover was formed, whereby the saturation point was reached.

The influence of the *relief* on the temperature pattern appears from many observations; reference should be made to figure 2 and plates I and II, which clearly show how the cold air concentrates in the bottom, where it will be further cooled down by outgoing radiation. As just stated the temperature distribution on routes 0 and 3 (fig. 8) also seems to provide evidence of the influence of the relief. However attention should be called to point 0 a, which is situated in the bottom of a gravel pit (fig. 1). The observations at this point clearly show that development of a frost hollow is totally missing. The height of point 0 a and 0 d is almost the same, but at point 0 a the surface is gravel and sand without vegetation, while at point 0 d it is covered by grass. This fact shows the necessity also to study the influence of the surface on the temperature distribution.

The results of the investigations concerning the influence of the *surface* on air masses close to the earth are reproduced in fig. 10-12. Fig. 10 firstly shows temperature inversions. The temperature increases by the height except in the lower part of the profile at station A. Secondly, it will be seen that the 10 cm level and partly the 50 cm level are coldest above the grass surfaces C and D. As the withered grass layer has a relatively bad conductivity the heat transport from the earth to the grass surface is impeded, and as

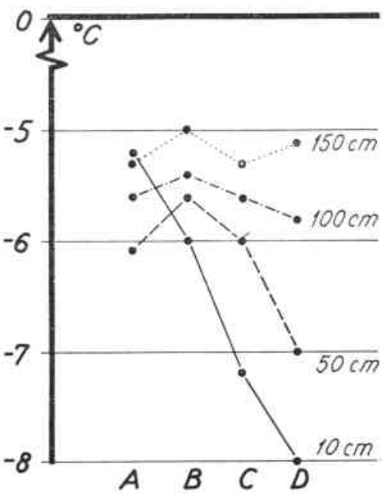

Fig. 10. Temperaturerne d. 14/3-1963 kl. 22.00 over fire forskellige overflader med få meters afstand imellem: harvet, tilsået (A), nypløjet (B), lavt græs (C) og højt græs (D). Linierne, der forbinder stationspunkterne, angiver de niveauer, i hvilke temperaturerne er målt.

Fig. 10. Temperatures 14.3.1963 at 22.00 h. above four different surfaces with only a few metres between: harrowed and sown (A), newly ploughed (B), low grass (C) and tall grass (D). The connecting lines between the points indicate the levels at which temperatures were taken.

the amount of heat liberated by radiation from surfaces of grass and bare ground respectively is approximately of the same size the result must be a greater cooling effect on the grass surface. However, the temperature differences between the two surfaces diminish relatively quickly by the height and become insignificant at a level of 150 cm. A comparison between the two grass surfaces shows lower temperatures above the high grass. The radiation surface of a high and dense vegetation lies at a higher level than is the case with a low and sparse vegetation, and consequently the high grass will cause lower temperatures at the 10 cm level and even more at 50 cm than a surface of low grass.

In the afternoon on March 23, 1963, measurements were made above grass and above snow at four levels (fig. 11). Above grass the 10 cm level is the warmest until 17.10 h., but hereafter the coldest. About 18.30 h. it clears up, radiation intensifies and has a decreasing effect on temperature at all levels. Simultaneously the temperature difference between the levels increases, and as it appeared from fig. 10 the decline is most evident at the 10 cm and the 50 cm level.

The snow surface – the temperature of which always being $\leqq 0°$ C – causes the 10 cm level to be colder than the other levels also during daytime, the other levels having nearly same temperature until 18.30 h. A comparison between the temperature profiles drawn of the two surfaces indicates that the two upper levels register the coldest temperatures above the snow during the whole period, though the difference is but slight. Before the clearance the 10 cm and the

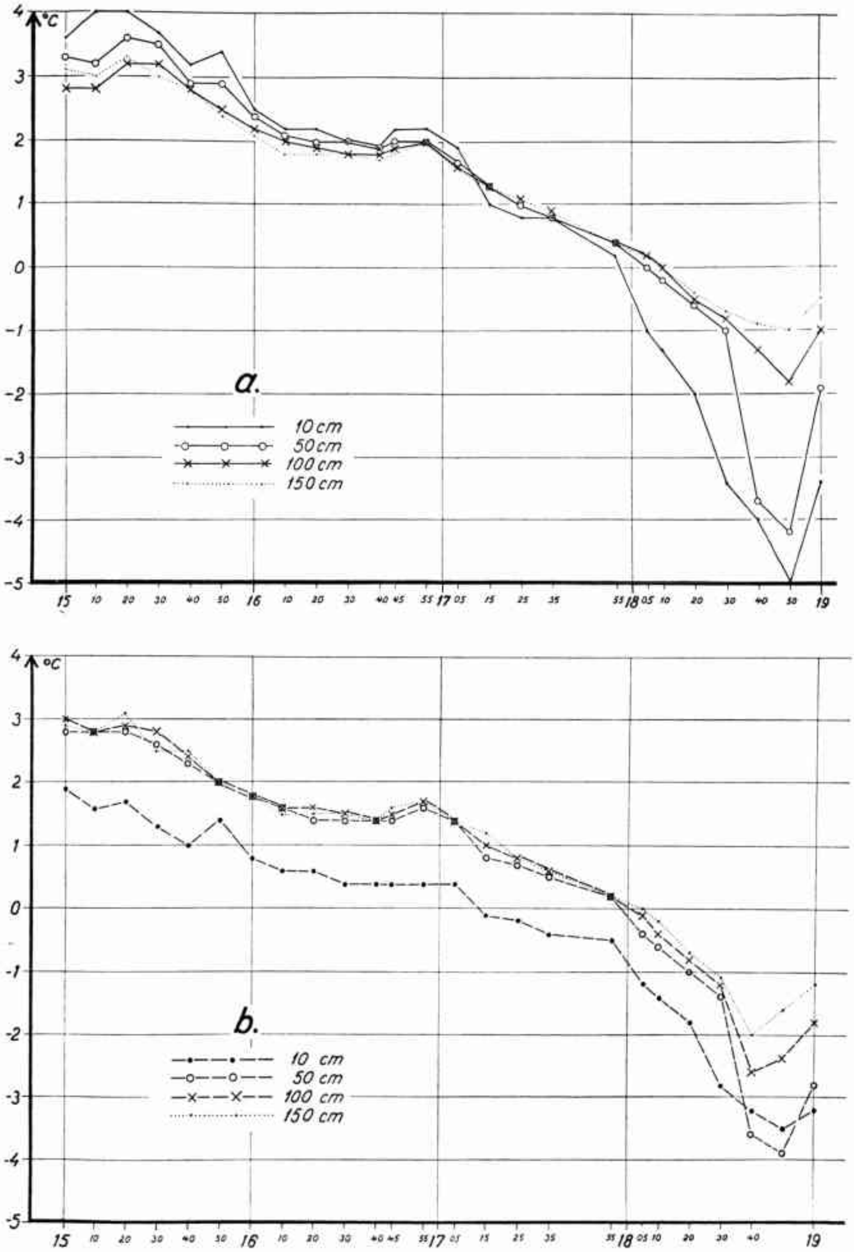

Fig. 11. Temperaturkurver for fire niveauer over højt græs (a) og over sne (b) d. 23/3-1963 kl. 15—19.

Fig. 11. Temperature graphs for four levels above tall grass (a) and above snow (b) 23.3.1963 between 15.00—19.00 h.

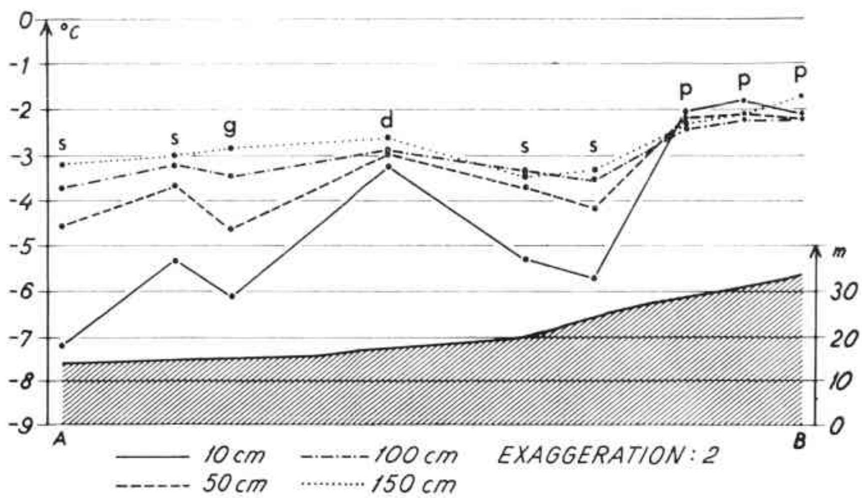

Fig. 12. Temperaturprofiler i fire niveauer på ruten mellem punkt A og punkt B om aftenen d. 1.12.1962. Nederst er angivet terrænprofilen, og overfladens beskaffenhed er antydet ud for målepunkterne: s = stubmark, g = græsvej, d = jordvej, p = pløjejord.

Fig. 12. Temperature profiles at four levels on the route between A and B in the evening 1.12.1962. At bottom, the relief profile. Nature of surface is indicated off the observation points as: s = stubble field, g = grass road, d = dirt road, p = ploughland.

50 cm level are likewise the coldest above the snow, while after then the radiation cools down the grass surface and thereby the air masses close to the earth to such an extent that the two levels now become the coldest above the grass.

Many of the factors discussed in the foregoing are reproduced in fig. 12, which permits an analysis of the interaction between terrain and surface determining the temperature distribution between point A and B. The figure shows the influence on temperature of the two factors independently. So, the terrain causes a fall in temperature on the stretch from point B on the hill to point A in the bottom of the adjacent valley, where the cold air has gathered, and this general fall in temperature is registered on basis of the profiles above, for example, the stubble fields. However, the temperatures show very irregular declines and here the character of the surface plays a decisive rôle. For the four types, grass road, stubble field, dirt road, and ploughland, the lowest temperatures are registered for the grass road and the stubble fields. The dirt road and the ploughland are without vegetation, the possibilities of conduction of terrestrial heat are good, and the temperature of the air near the surface is relatively high. The highly developed inversion above the two cold surface types is significant, whereas the inversion is weak above the dirt road and almost undistinguishable above the ploughland. The measurements at the 10 cm level reflect most explicitly the cooled earth surface and its varied character, but the higher the level the smaller the influence of these factors on temperature, as it is obvious from the temperature profiles at 50 cm, 100 cm and 150 cm levels.

The regional temperature distribution

As a supplement to the studies of minor locations it was decided to make observation drives over longer stretches; the data thus collected would throw light on the regional temperature distribution over a bigger area and extend the knowledge of the influence of relief, vegetation and residental areas. A route was laid out into all directions from the town Lille Værløse; it covered town centre, residental neighbourhood as well as forest and open fields with levels varying from 15 m above sea level south of lake Sønderso to about 50 m above sea level around Lille Værløse. Further, a great part of the already studied locations around the village Kirke Værløse was included. Route and levels are shown in plate I-II, land-use in fig. 13.

On the car a resistance thermometer was mounted about 2 m above road level. The route was driven through at a constant speed – abt. 25 km/hr. – and readings of the temperature were made so frequently that measurements were taken every 30 m.

In order to illustrate best possible the interaction between the various factors the measurements should preferably be made on a cold evening with strong radiation, thus giving a temperature development of the previously mentioned type I. Further, measurements should be made during a period with a moderate and uniform decline of temperature, as this will secure the most reliable comparison between temperatures within the region. The circumstances wanted occurred during the night between March 7 and 8, 1964, and the measurements were taken between 21.30 and 0.55 h. Three observation drives were made, two of them covering the whole route, while the third one was shortened somewhat. On basis hereof two plates were worked up showing the regional temperature distribution at 22.00 h. and 23.15 h. respectively. The individual temperature observations are corrected as regards time so they represent the conditions in the middle of each drive. The corrections are made on basis of a thermograph curve from station B east of Kirke Værløse; the course of this curve is compared with declines in temperature

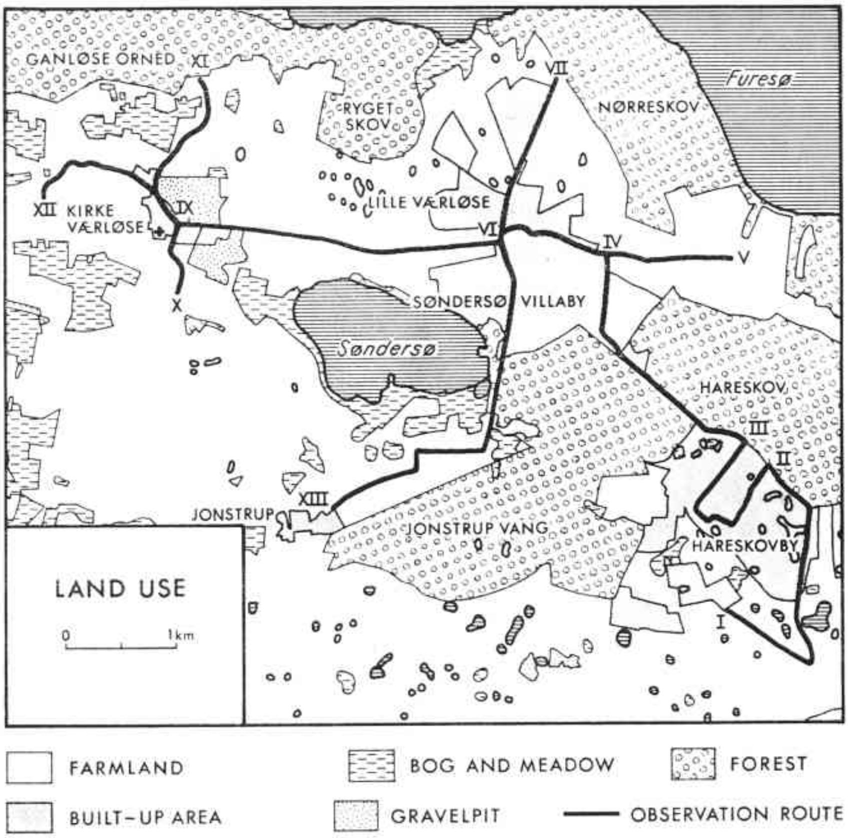

Fig. 13. Kort over arealudnyttelsen. På måleruterne er angivet de punkter, hvortil der refereres i teksten.

Fig. 13. Map of the land-use. The points referred to in the text are indicated on the observation routes.

registered at several of the fixed observation places passed during the said night. A somewhat uniform decline of temperature was ascertained over the whole region. The corrections are greatest for the first drive in the region around Kirke Værløse, the maximal corrections here being 1.4 degrees, whereas for the second drive corrections are only made from ÷ 0.5 to + 0.4 degrees for observations deviating mostly in time from 23.15 h. When drawing the plates the small lag of the resistance thermometer – which fig. 2 apparently reveals – has not been taken into account.

The first impression of the temperature distribution is that the region observed splits into two parts. On both plates the plateau around Lille Værløse and towards Kirke Værløse appears to be the warmest, whereas the valleys – the areas below 30 m – show a temperature a few degrees lower. The maximum difference in temperature within the region was 3.5 to 4.0 degrees; thus, highest and lowest temperature (corrected) were at 22.00 h.: ÷ 5.1° C and ÷ 8.5° C, and at 23.15 h.: ÷ 5,9° C and ÷ 9.8° C respectively. A corresponding variation of about 3 degrees was registered during the last drive (0.30 h.) where unfortunately the observations of the lower parts were not carried through.

Also a closer study of separate parts of the route shows very good accord between the two observation drives. So, on the distance I–II (cf. indication of route in fig. 13) the highest temperatures were registered along the slopes on all three drives, though the difference between valley bottom and slope lies within one degree. A somewhat lower temperature apparently characterizes the route between II and III in the middle of the residental area Hareskovby. After point III, the temperature increases at all three observations of the night by 1 to 2 degrees compared with the loop into the valley, but on entering the forest Hareskoven a fall in temperature is registered. Through the forest there is a slight increase in temperature, which appears most obviously from plate II and is supported by the later measurements at 0.30 h.; but the warm region on the plateau (50 m above sea level) does not show until out of the forest again, and on the whole, higher temperatures dominate the stretches V-VI, VI-VII, and VI-IX whether they go through residental areas or countryside; it must be added, however, that the three observation drives all registered highest temperature in the town Lille Værløse. This permits the supposition that the urban area intensifies the warm region.

The observation route south of Lille Værløse towards Jonstrup (VI-XIII) represents the extremely cold region with declining temperatures on the way down into the valley east of the lake Søndersø. On the lower part of the route south of the lake (15-20 m above sea level) temperatures between ÷ 8.5 and ÷ 9.8 degrees were measured at 23.15 h. against ÷ 5.5 and ÷ 6.5 degrees in the centre of Lille Værløse; and both at 22.00 h. and 23.15 h. the coldest stretch coincided with the place where the 15 m level is passed. Possibly this tendency of frost hollows is to some extent intensified by the existing vegetation of meadows and bogs.

The western part of the observation field around Kirke Værløse shows the same tendencies with the coldest areas in the valley Bundsådalen and towards the bog Oremose (cf. fig. 1); thus, the stretch IX-XII has a similar temperature distribution as previous measurements showed in fig. 2.

On basis of the experience gained by long-term observations at Kirke Værløse it might be concluded that temperature differences of at least 2-3 degrees between plateaux and valleys will occur during 10-20 % of the year (see fig. 5). The fact that this contrast appears most frequently during wintertime makes it natural to point to the consequence of such an investigation on town-planning so that dwelling areas should be placed on the plateaux instead of in valley areas with their extreme cold values. Finally, it should be added that the results discussed in this paper are based on relatively few measurements, but a technique has been elaborated and experience gained which it would be natural to exploit and extend before planning new residental areas.

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