The Severe Winter in Europe 1941–42: The Large-scale Circulation, Cut-off Lows, and Blocking

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Abstract

The winter of 1941–42 is known as the coldest European winter of the 20th Century. The temperature was much below normal from the beginning of January until the end of March 1942. Blockings and cut-off lows were frequent, particularly during January and February 1942.

The role of quasi-stationary waves during this winter has been studied by decomposing the 500-mb geopotential height data in a low-pass, filtered, quasi-stationary part and a traveling part. The phase of the quasi-stationary wave was such that a ridge was present over the eastern Atlantic and a trough over western Russia throughout most of the winter. As a result, the majority of migratory cyclones that approached Europe from the west were steered either south toward the Mediterranian or north of Scandinavia.

The synoptic course of events during an outbreak of unusually cold air from the northeast at the end of January 1942 is described in some detail. Some comments are given on how the severe winter weather affected the war in the USSR.

1. Introduction

Several of the winters during World War II were very cold in Europe. The winter of 1941–42 is known as the coldest winter during the 20th century. There are numerous narratives about soldiers in eastern Europe who died from freezing. This has been documented in chronicles of the war. Ice conditions in the Baltic and adjacent seas are good indicators of how cold a winter in this part of the world is. A map showing the average ice conditions during the time period 8 February through 16 March 1942 is presented in figure 1 along with a corresponding map for a normal winter, in this case for the time period 1–27 February 1937. The map for 1942 suggets that the cold period must have been long.

The political situation in Europe during the winter of 1941–42 is illustrated in figure 2. World War II began on 1 September 1939. During the first years of the war the Axis were successful and several countries were occupied. Apart from some neutral countries the Axis controlled most of Europe by the summer of 1941. On 22 June 1941 Germany started a war against the USSR.

The cold weather has also been documented in meteorological literature. In particular, the synoptic course of events during the outbreak of extremely cold arctic air in January 1942 has generated interest (see, for instance, Scherhag 1948). The impact of the cold weather on the German troops in Russia has recently been discussed by Neumann and Flohn (1987). Common to these works and others is that they deal with the cold spells. Perhaps because of the limited amount of available data, they do not address in detail the large-scale tropospheric flow pattern that caused the anomalous conditions.[1] Because of the war, exchange of meteorological information did not take place in the normal way. Official weather maps contained data from only a limited part of Europe. After the war, the U.S. Weather Bureau collected available surface measurements and reanalyzed maps for the whole Northern Hemisphere. Upper-level data, however, have not been assimilated in the same way. The best available, upper-level data are daily maps covering most of Europe published by the German Weather Service. These maps were kept secret during the war but became available later.

A visual inspection of the maps reveals that several blocking episodes and cut-off cyclones appeared during the winter of 1941–42. The purpose of this paper is to discover how frequent these weather situations were, and to document the role of planetary-scale waves in establishing the circulation pattern during this winter. We also discuss at some length the outbreak of extremely cold air in January 1942. The paper is organized as follows. The data are described in section 2. In section 3 the large-scale flow is discussed, and in section 4 the synoptic cause of events that occurred during the passage of a cut-off low over the Baltic at the end of January 1942 is described. Finally, we give some comments on how the severe winter weather affected the war in the USSR.

2. Data

Most of the data used in this study have been published by the German Weather Service. The Germans

[1] Footnote no. 4 in Neumann and Flohn (1987) announces a forthcoming article on this topic.

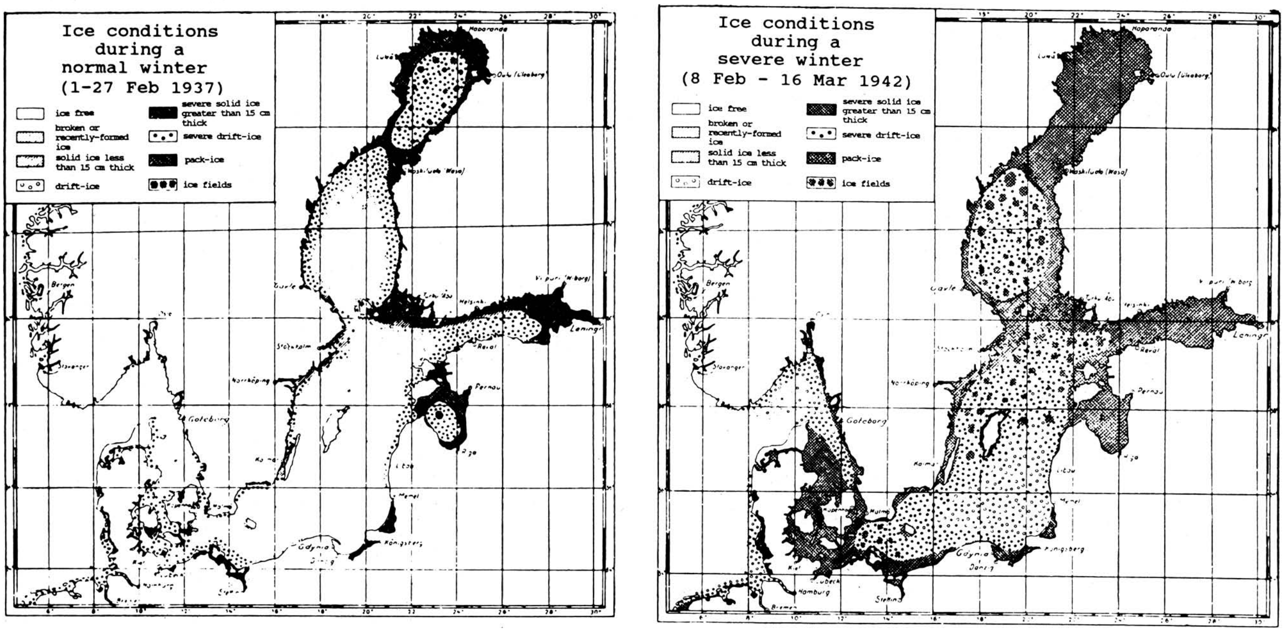

FIG. 1. Ice conditions in the Baltic during a normal winter (to the left), and during the winter 1941–42 (to the right). (From Liljequist 1962.)

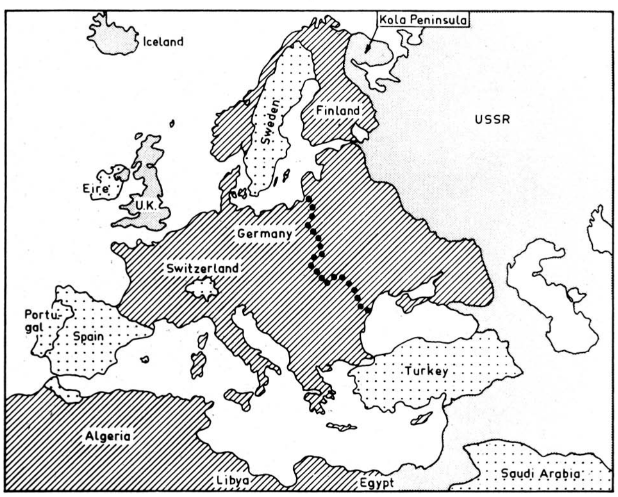

FIG. 2. The political situation in Europe during the winter of 1941–42. Areas controlled by the Axis are hatched, and areas controlled by the Allies are shaded. Neutral countries are stippled. The dotted line shows the border between Germany and the USSR before Germany's war on the USSR started on 22 June 1941.

received data from the major part of Europe, except of course the British Isles, and, occasionally, Sweden. For this reason, some data have been taken from maps analyzed by the British and Swedish Weather Services. We used surface analyses, 500-mb maps, and radiosonde data. The maps extend from 40° to 70°N and from 10°W to 40°E, except the 500-mb maps for 1941 that extend only to 65°N. Data for the 500-mb surface were extracted by digitizing the height above mean sea level for every 5 degrees of latitude and longitude. The published height values are given in geodynamical meters, a unit that was used by the German Weather Service at that time. We multiplied them by a factor of 1.02 in order to obtain the geopotential height. We decided to use geopotential height in this study since this is what is used today.

3. The large-scale flow

a. Cut-off lows and migratory cyclones

Cut-off cyclones are characterized by a flow pattern with a 500-mb geopotential height decreasing equatorward. The same is true for most blocking situations. Lejenäs and Økland (1983), for instance, used criteria focusing on this kinematic property of the flow field to identify blockings. The weather maps for the time period we studied indicate that blockings were frequent during this winter. However, since the area investigated here has a limited geographical extent, it was not possible to identify all cases with blocked flow with the same criteria as Lejenäs and Økland used. Nor was it possible to adopt classical criteria like those of Rex (1950) (because of the extent of the area), or to count persistent positive anomalies lasting for a certain number of days, as Dole and Gordon (1983) did (because we did not have access to a climatological 500-mb map for the early 1940s). To evaluate the frequency of cut-off cyclones, we computed an index defined as

$$I(\lambda, t) = Z_{45°N}(\lambda, t) - Z_{65°N}(\lambda, t) \qquad (1)$$

where Z is the geopotential height and λ is the longitude. This index is negative if cut-off lows and/or blockings are present. The reason why 65°N was chosen as the northernmost latitude is that a blocking

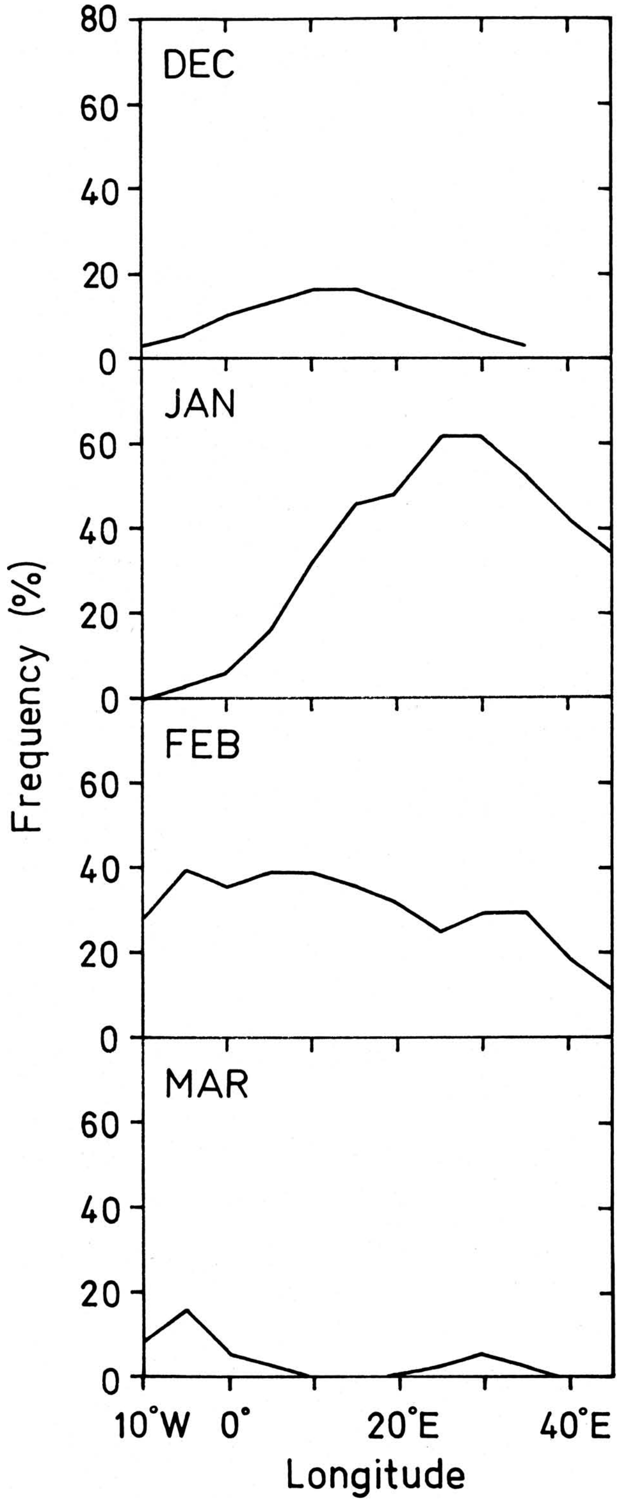

FIG. 3. Frequency of days when the 500-mb geopotential height at 45°N was lower than that at 65°N (at the same longitude) as a function of longitude for December 1941, January, February, and March 1942.

high was present over the Kola Peninsula northeast of Finland during part of the winter. We counted the number of days the index was less than zero. By doing so, we were not able to separate out those weather situations when only cut-off lows appeared, i.e. when

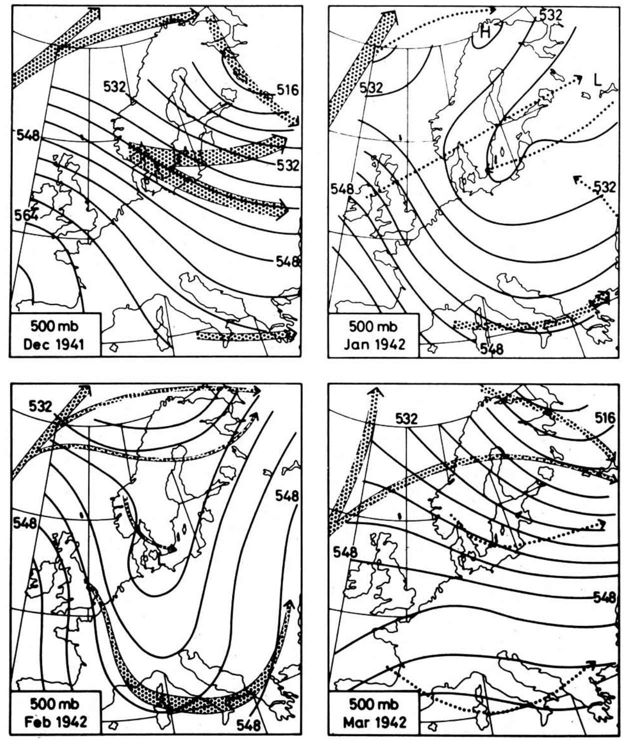

FIG. 4. The monthly mean 500-mb geopotential heights during December 1941, January, February, and March 1942 and storm tracks for these months. Tracks of the migratory surface cyclones are indicated with stippled arrows and dotted lines. The width of these give, subjectively, the number of cyclones involved.

there were no blockings. This is, however, not of crucial importance to this study. The only thing that should be remembered is that the occurrence of a negative index below contains both types of weather situations.

The relative frequency or percentage of days with negative index is shown in figure 3 for the months December 1941, January, February, and March 1942. The maximum for December is 18% at 10°E and 15°E because a cut-off low was present over the Mediterranean, and a trough extending from western Russia to the Mediterranean occurred during a cold-air outbreak. The 500-mb monthly mean map for December is shown in figure 4a. Tracks of the migratory surface cyclones have been indicated with stippled arrows. The width of the arrows subjectively indicates the number of cyclones involved. Several cyclones passed northwest of Scandinavia, and some of them proceeded towards the south over northwestern Russia. A number of cyclones developed over southern Scandinavia as occluded fronts approached from southwest. These lows moved eastwards towards the Baltic and western Russia.

The weather situation during January 1942 differed much from that of the previous month (see the 500-mb mean map in figure 4b). Mild southwesterly surface winds swept over Scandinavia and Finland the five first days. Northerly winds followed a low that

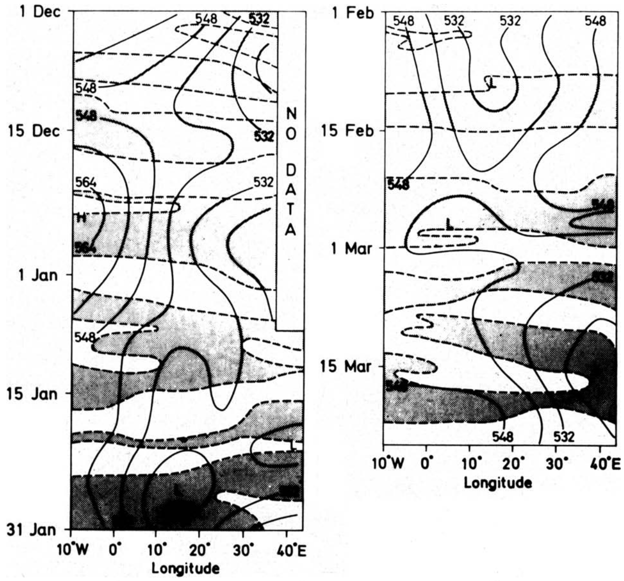

FIG. 5. Time-longitude diagram for the period 1 December 1941 through 25 March 1942 showing quasi-stationary (full lines) and traveling (dashed lines) waves at 55°N. Areas with negative values of the traveling wave geopotential height are shaded. For the definition of stationary and traveling waves see text. The heights are given in geopotential decameters. There appears to be a discontinuity in the shaded areas from 31 January to 1 February. However, the dashed line at 35°N on 31 January ends up at 10°W on 1 February.

passed over middle Sweden and Finland on 5 January (figure 4b), establishing a quite different weather situation. An anticyclone over southern Sweden strengthened and moved slowly northeastward to the Kola Peninsula where it stayed for the rest of the month. The circulation resembled that of a blocking situation in that an omega-pattern was established. In this way it was possible for the very cold air to move westward. There were not many migratory cyclones present over Europe during January, except over the Mediterranean and northwest of Scandinavia. Most of the time the cold air covered Europe east of a line from the North Sea to the Balkan Peninsula. The frequency of days with blocked flow was much higher in January 1942 than in December 1941, with a maximum of 60% at 25°E and 30°E (figure 3).

At the end of January 1942 the cyclone activity over the Mediterranean increased. A major 500-mb trough was present over middle Europe during February (figure 4c), and the number of days with negative index was somewhat smaller than in January; a maximum of about 40% at 5°E and 10°E (figure 3) but uniform across the sector. A widespread anticyclone dominated western Russia most of the time, and the surface temperatures were very low. There were not many migratory cyclones present over central Europe.

In March 1942 there were few days with negative index (figure 3). The monthly mean map for the 500-mb flow (figure 4d) shows a fairly zonal current. In the first two weeks, cyclones were frequent west and east of Scandinavia with a ridge in between, and during the second half of March mild air swept over the northern coasts of Scandinavia. Broadly seen, the arctic conditions dominated most of Russia from the beginning of December 1941. The large-scale trough did not move westwards until 5 January 1942. From then on, the cold air swept over northeastern Europe throughout January and February. In March the large-scale flow returned to a more normal zonal state.

b. Quasi-stationary and traveling waves

The monthly mean maps in figure 4 for the 500-mb flow give an overview of the large-scale flow pattern. A better understanding of the flow can be obtained by studying low- and high-pass filtered data. The 500-mb geopotential height data were decomposed into a low-pass filtered quasi-stationary or stationary part, and into a traveling part defined as the difference between the observed and the filtered values. A Parzen window, equivalent to a power window of degree 3 (see for instance Båth 1974), was applied to the data, and 15 consecutive days were used to obtain the stationary wave. The response function of this filter is almost the same as that of a running average, except that it has the advantage that the frequency spectrum has no negative sidelobes. An interval of 15 days was chosen as this was considered to be a time scale characteristic of blocking.

Height fields of the quasi-stationary and traveling waves were evaluated for December 1941, January, February, and March 1942. Here, we present the results in a time-longitude (Hovmöller) diagram for latitude 55°N (figure 5). Data for this latitude were chosen since the index defined in (1) was computed from data for 45° and 65°N. Similar diagrams for 50°N, 60°N and 65°N were made; they all were essentially the same as the one for 55°N.

Figure 5 reveals that the phase of the stationary wave was such that a ridge was present over the eastern Atlantic (10°W, 55°N) and a trough was present over Western Russia throughout most of the winter. Traveling waves moved eastwards during December and the first two weeks of January. An eastward-moving cyclone weakened the ridge at the end of January, although it was reestablished later. This behavior of the stationary wave with a ridge and a trough almost in the same position throughout the winter had a strong impact on the length of the cold period. Very cold air over Siberia was able to penetrate westwards throughout January and February.

The rapid fluctuation in the traveling component (shaded in figure 5) is somewhat puzzling. In some cases the traveling component passes through the sector in a little more than one day. Visual inspection of corresponding maps did not confirm the passage of a low or a trough, and therefore some of the traveling components with high phase velocity are probably artificial. Presumably they are introduced because the routine analyses were made by hand. Observational errors might also have been made.

4. A cut-off low over northeastern Europe at the end of January 1942

Towards the end of January 1942 a cut-off low with unusually cold air propagated westward from Siberia. It matured over the southeastern Baltic and continued to southern Sweden where it was gradually filled. It was typical of cold upper-level lows that occur when domes of cold air occasionally appear over northeastern Europe during the winter, although the temperature of this feature was more depressed than usual. This cut-off low has been described to some extent elsewhere (see for instance, Scherhag 1948 and Neumann and Flohn 1987) although the lack of data, partly because of the war, has made a detailed study impossible. Here some information that to our knowledge has not ben published before is presented. Similar studies of cold lows have appeared in the literature, for example, Palmén (1949), Meyers (1949), Peltonen (1963), Boyden (1963), Takeuchi and Iida (1967), and Miller and Carlson (1970).

The surface low that passed over middle Sweden and Finland on 5–6 January 1942 deepened substantially over western Russia. The upper-level trough developed into a low that became almost stationary south of the Kola Peninsula (the geographical location is given in figure 2), remaining there for more than a week. On 16 January it was split up into two separate lows, one quasi-stationary over Germany and another that moved eastward. The eastward-moving cyclone later merged with very cold air from Siberia, and started to move westward again. On 22 January the cyclone was centered southeast of Moscow. The minimum 500-mb geopotential height (Z_{min}) was 514 gpm, and the lowest reported temperature (T_{min}) was −39°C. In the days that followed it deepened as it moved westwards and the temperature in the center dropped. Positions of the 500-mb cyclone center on 23–31 January are shown in figure 6, and the 500-mb maps are found in figure 7. On 23 January Z_{min} was 510 gpm and T_{min} close to Moscow was −40°C. On the following day, 24 January, Z_{min} was 494 gpm and T_{min} was −41°C just south of Leningrad. The cyclone intensified the next day (25 January) over the southeastern Baltic where Z_{min} was 479 gpm and T_{min} (over southern Finland) was −43°C. From then on it slowly decayed over southern Sweden (on 26 January Z_{min} was 488 gpm and T_{min} − 43°C), where it stayed another 6 days, until 1 February. Following this time, a new trough formed over the North Sea, the first in

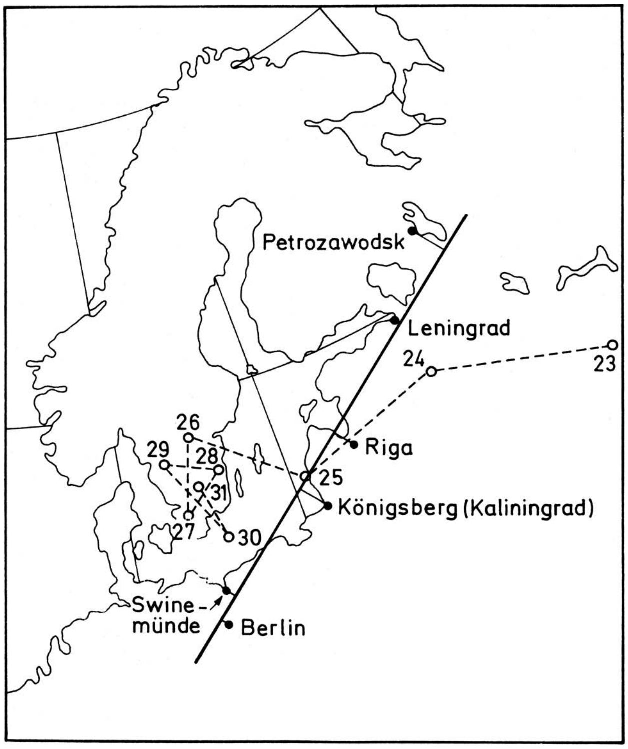

FIG. 6. The track of the 500-mb low 23–31 January 1942 (dashed line). The open circles show the position of the low at 07 GMT every day. Also shown are the positions of the stations used to construct the section shown in FIG. 9.

a series of troughs that dominated central Europe for most of February 1942.

In Königsberg (today Kaliningrad in the USSR) the surface temperature was −34°C on the morning of 25 January. According to Scherhag (1948), who discussed this low as an example of cut-off cyclones, it was the lowest surface temperature in this part of the world since 16 January 1813. The upper-level cyclone was not accompanied by a surface low, only a trough. Surface maps for 23–26 January are presented in figure 8. The winds were strong (15–20 $m \cdot s^{-1}$) and gusty when the air swept from the northeast over the Baltic. The cold air continued westward, and reached the North Sea (it also penetrated down to the Balkan peninsula). The reason it did not advance further was that strong northwesterly winds persisted over western Europe. Surface temperature at Calais at the English Channel was +4°C, which means that there was a temperature difference of 38°C between southeastern Baltic and the English Channel, a distance of about 1600 km.

A section from Berlin, Germany, to Petrozavodsk, USSR, (61.2°N, 34.3°E) at the western shore of lake Onega through the cut-off low on the morning of 25 January 1942 is shown in figure 9. The positions of the stations used to construct the section are shown in figure 6. The data used were extracted from radiosonde data published by the German Weather Ser-

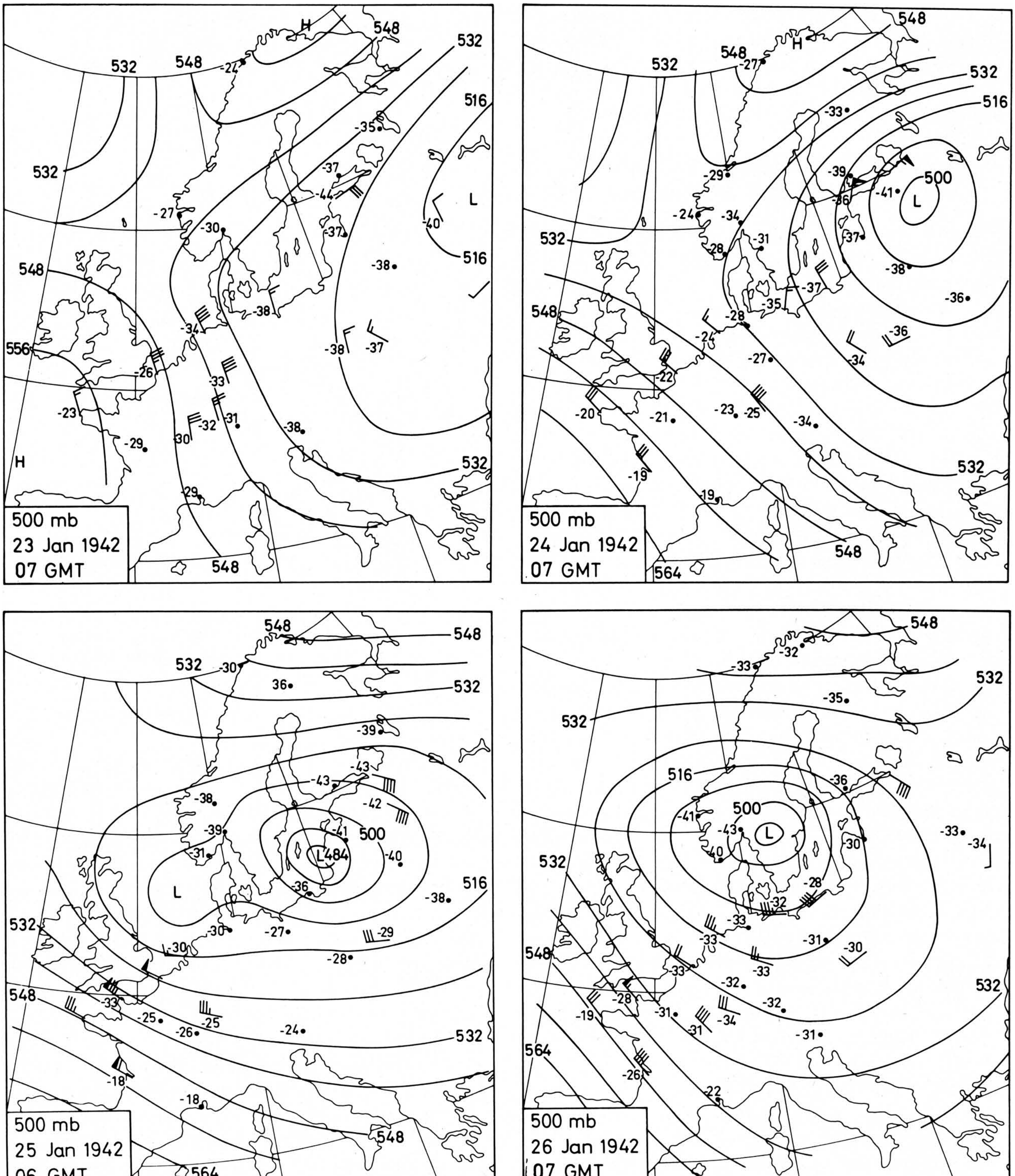

FIG. 7. 500-mb geopotential height 07 GMT 23–26 January 1942.

vice. Unfortunately, wind measurements are available only from Swinemünde, Germany, and the German weather station 25 km southwest of Leningrad, USSR. Therefore we estimated the geostrophic wind from the geopotential height data, and these winds have been incorporated in figure 9. It should be noticed that the flow was cyclonically curved, which means that the real winds were not as high as the geostrophic wind. The isotachs (dashed lines) reveal two jet streams, a northwesterly jet close to Swinemünde and a southeasterly jet between Riga and Königsberg respectively. Due to lack of data it was not possible to determine the maximum wind velocities. The isoterms (thin lines) show that the cold air had a diameter of about 500 km in the lower troposphere (700 mb), and the extent decreased with height. The vortex axis was almost vertical. The strong horizontal temperature gradients on each side of the cold air

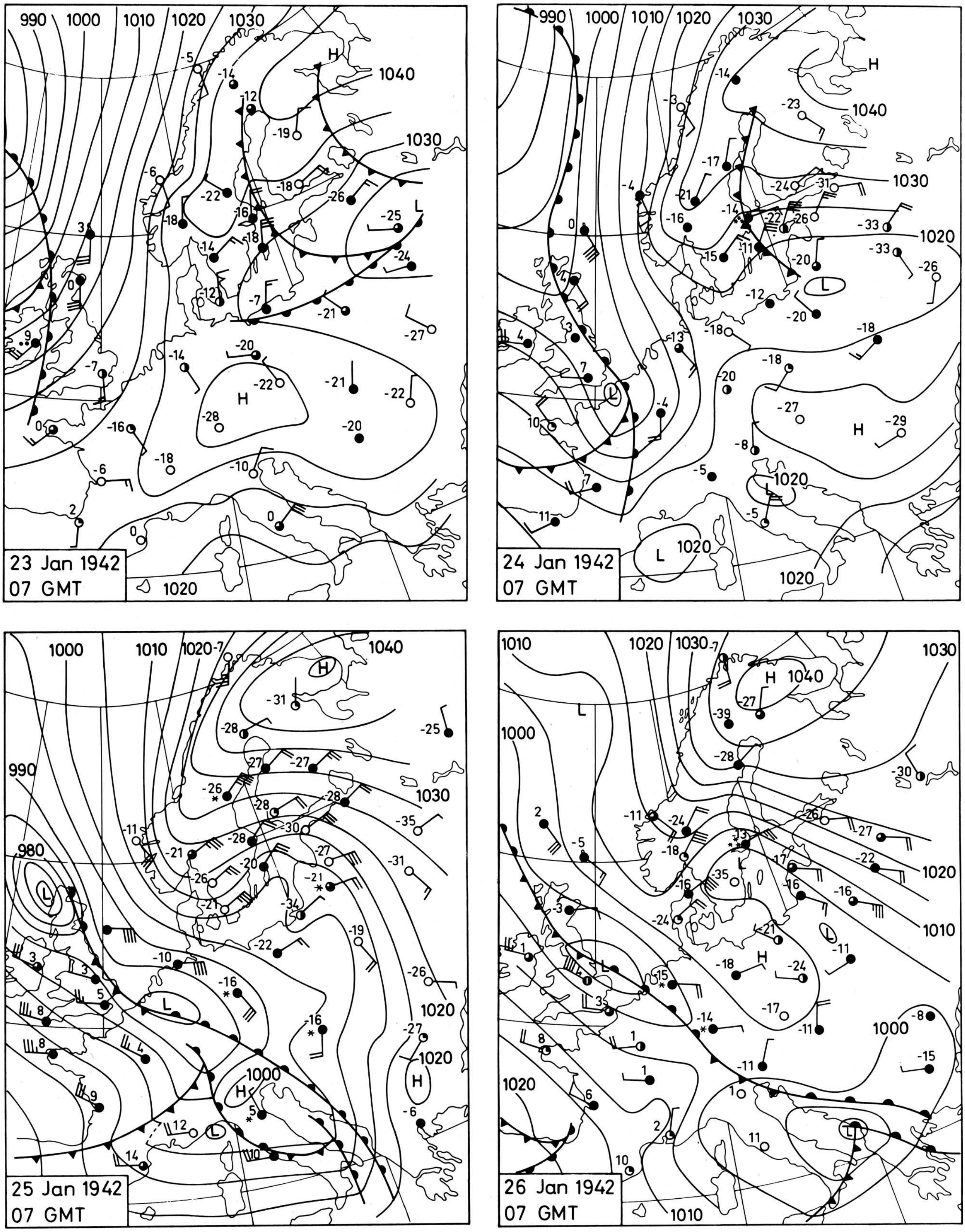

FIG. 8. Surface maps 07 GMT 23–26 January 1942.

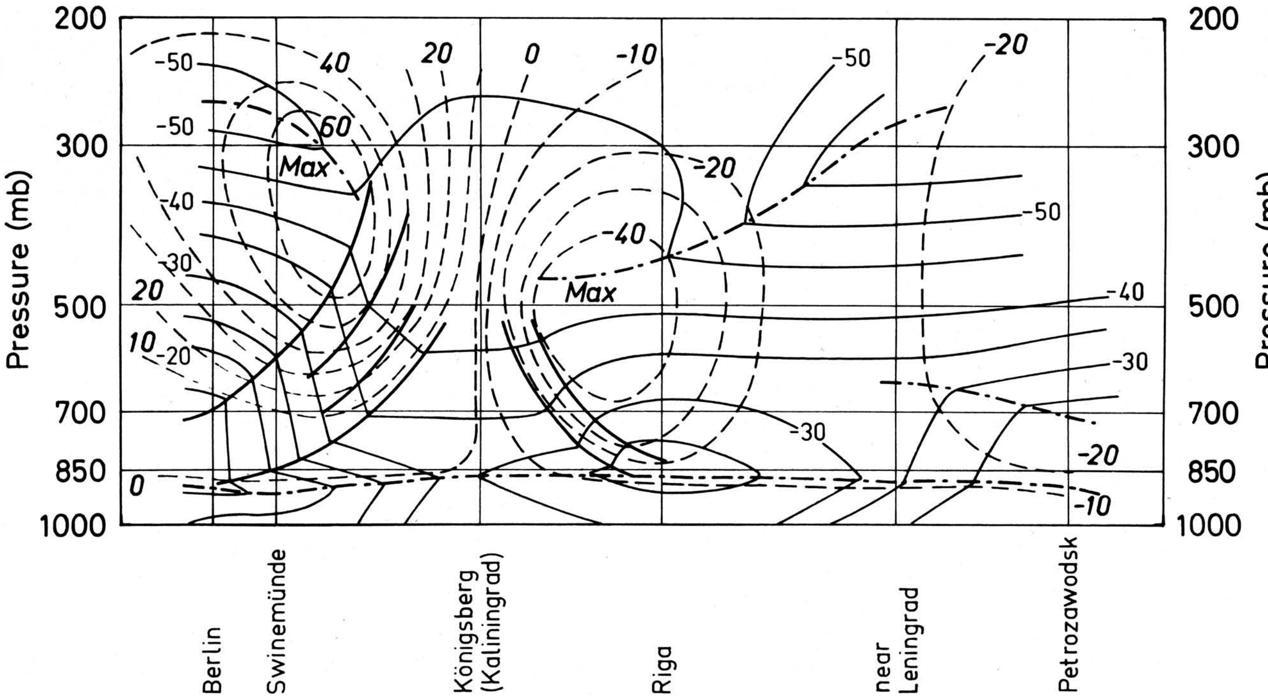

FIG. 9. Section through the cut-off low on 07 GMT 25 January 1942 from Berlin, Germany to Petrozawodsk, USSR (61.2°N, 34.3°E). The Leningrad sounding was made by the Germans 25 km southwest of the city. Thin solid lines are isoterms in °C, thick solid lines are fronts and dashed lines are isotachs in m · s^{-1}. The wind velocity refers to the wind component perpendicular to the section, and positive values means northwesterly winds. The tropopause and stable layers are indicated with dash-dotted lines.

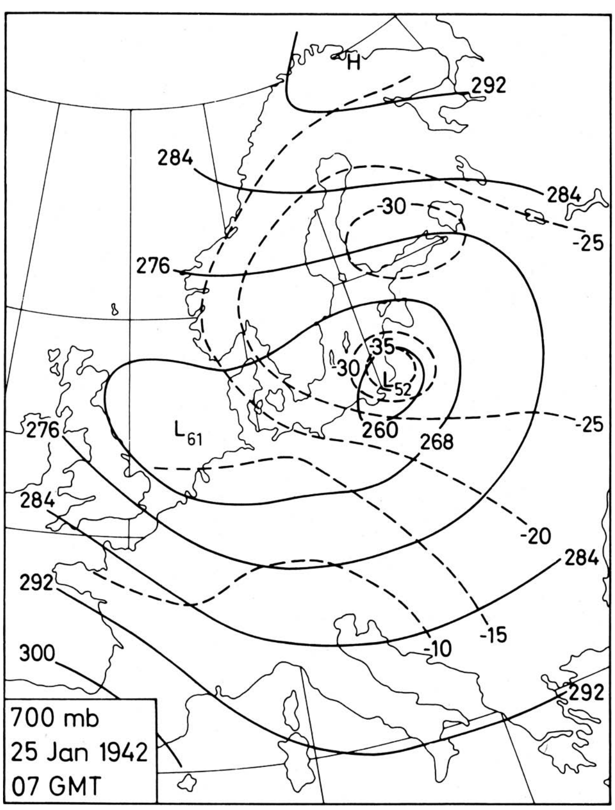

FIG. 10. 700-mb geopotential height 07 GMT 25 January 1942. The heights are given in decameters. Also shown are isoterms (in °C).

explain why the surface trough intensified with height. The low 500-mb temperatures were mentioned earlier. Radiosonde data reveal that the 700-mb temperature over Königsberg (Kaliningrad) was −37°C (figure 10). This is also a remarkably low temperature. As the low passed, the temperature dropped 10–20°C throughout most of the lower troposphere. This can be seen in figure 11, which shows three consecutive temperature soundings from this station made just before, during, and after the passage. Horizontal advection of warmer air most likely was the main reason for the temperature increase after the passage of the low.

Cut-off lows with extremely cold air like the one in January 1942 are very rare in this part of the world. Only once more during this century has a similar weather situation occurred. It was around 10 January 1987 when a cut-off cyclone moved from the Kola Peninsula over Finland and Sweden and further southward to middle Europe. At that time the air was as cold as during 1942. A comparison of surface data from Stockholm, for instance, reveals that the lowest temperature was measured on 25 January 1942 (−28°C at 0600 GMT), although the mean temperature was lower in January 1987. During four days, 9–12 January, the mean temperature at the downtown observatory of Stockholm was lower than −20°C. This had not occurred since the measurements began

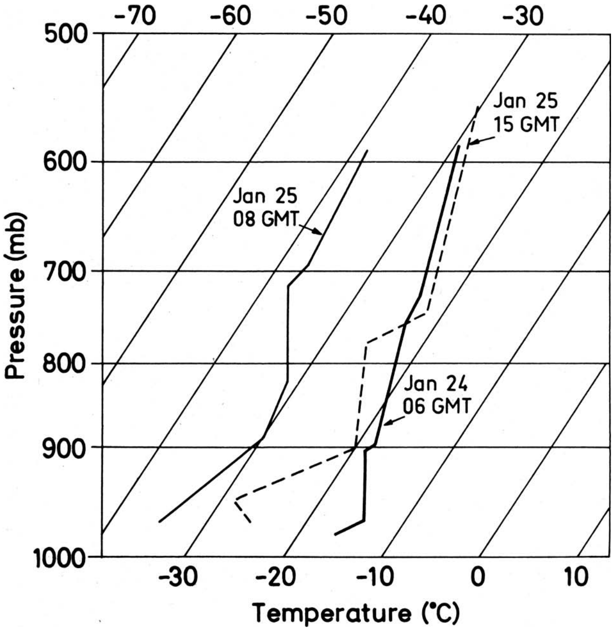

FIG. 11. Temperature soundings at Königsberg (today Kaliningrad) before (thick solid line), during (thin solid line) and after (dashed line) the passage of the cold air dome 24–25 January 1942. The location of Kaliningrad is shown in FIG. 6.

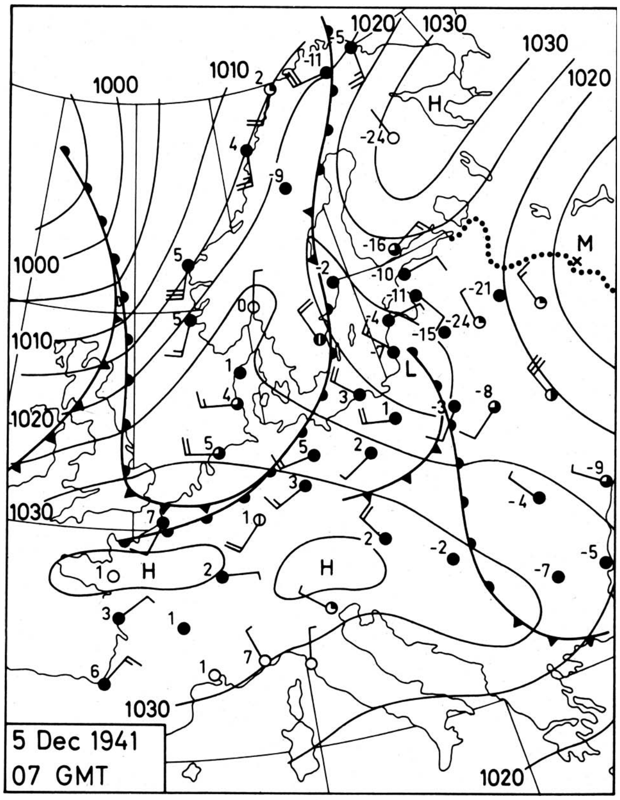

FIG. 12. Surface map 07 GMT 5 December 1941. The dotted line shows the position of the military front in Germany's war on the USSR, and M shows the location of Moscow.

in 1756. The values were −20.5°C, −23.9°C, −21.6°C, and −20.4°C respectively. On 25 January 1942 the mean temperature was −23.7°C.

5. The importance of the severe winter weather for the war in the USSR 1941–42

There is abundant literature on the severe winter weather that posed serious problems to German troops in Russia during World War II. Neumann and Flohn (1987) have discussed this at some length. It is clear that the reason why the Germans had to relinquish their attack on Moscow on 8 December 1941 was that their troops lacked winter clothing, and that their equipment malfunctioned due to the snow and extremely cold weather. The inadequate clothing was due to the German High Command being convinced that the war would end before the arrival of winter, although a more normal winter with somewhat milder conditions would not have changed the history. Nevertheless, cold arctic air with surface temperatures betwen −20° and −30°C, and occasionally even lower was present over the western parts of the USSR and Finland during most of December 1941. Surface cyclones moved from southern Sweden towards the southeast (figure 4a). The surface map for 5 December 1941 presented in figure 12 is typical for the weather during this month. On this day, German Panzers were as close as 15–30 km from the city limits of Moscow. The dotted line in figure 12 shows the approximate position of the military front. Three days later the German offensive was over, although it took several more years before the war came to an end. The military front became more or less stationary during the winter of 1941–42. Then followed several attacks and counter-attacks until January 1943 when the Germans lost the battle of Stalingrad. From then on they were slowly forced out of Russia, and in April 1945 when Allied troops reached Berlin the war in Europe was over.

The morning temperatures at some selected cities are presented in figure 13 as an illustration of the cold weather. The temperatures at Moscow for part of November and December 1941 originate from Zhukov (1984), although they can also be found in Neumann and Flohn (1987). Corresponding data for January through March 1942 are the official 07 local time temperatures in Moscow. The official data from Leningrad and Moscow are of great interest to those who are involved in detailed studies of the impact of the cold weather on the war. Since we were not able to find them in any easily available publication, they are reproduced in table 1.

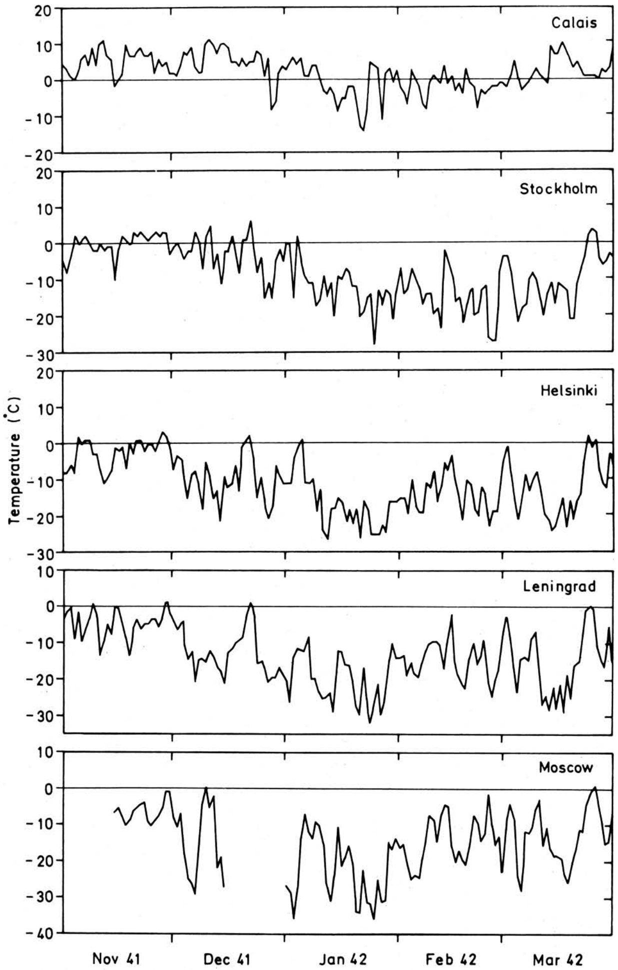

FIG. 13. The morning temperature as a function of time for the period 1 November 1941 through 31 March 1942 for some European cities. The temperatures at Calais (at the English Channel), Stockholm, and Helsinki are from 07 GMT, whereas those at Leningrad and Moscow are from 07 local time.

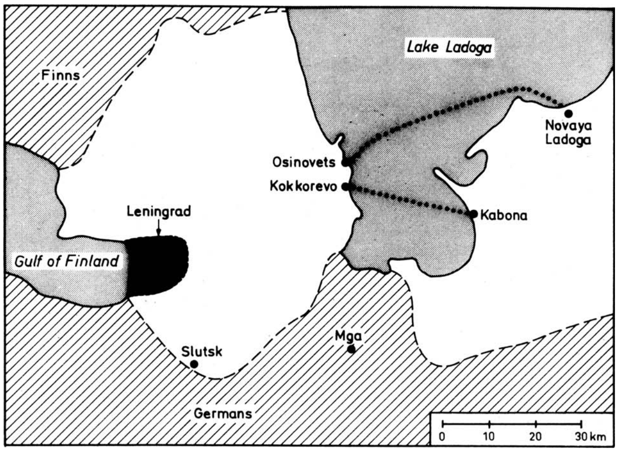

FIG. 14. Map showing the position of the Axis armies during the siege of Leningrad 8 September 1941 through 27 January 1944. Water (Lake Ladoga and Gulf of Finland) is shaded, and land areas are white (territory in Russian possession) and hatched (occupied by the Germans or the Finns, who were allied with the Germans). The dotted lines indicate the routes that were used for transporting goods to Leningrad.

One tragedy of the war during the winter of 1941–42 was the siege of Leningrad. The plight of Leningrad during the winter 1941–42 has been documented in chronicles of the war, including Neumann and Flohn (1987). From 8 September 1941, the city was surrounded by Axis armies—the Germans to the south, and the Finns to the north (figure 14). East and west of the city lies open water, Lake Ladoga and the Gulf of Finland, respectively. All connections by road and railway to the rest of the USSR were cut off. The authorities in Leningrad were not prepared for a siege; all efforts were concentrated on the defence of the city against the Germans. As a consequence of the disruption of commerce, numerous people died from starvation. The extremely cold weather and German bombing also caused many deaths. According to official calculations 260,000 people died during the winter of 1941–42, although it is believed that in reality it was somewhat more than one million.

Anomalously cold weather was partly beneficial to the citizens of Leningrad. Since it was not possible to supply food and equipment overland, barges were used to transport goods on Lake Ladoga from Novaya Ladoga on the eastern shore (figure 14) to Osinovets on the western shore. There was a railway connection between Osinovets and Leningrad. The barges were slow; they needed 16 hours to cross the lake. It was an easy task for the German bombers to eliminate them. On an average, the barges transported less than one thousandth of the food Leningrad needed each day. However, Lake Ladoga froze early that winter, which turned out to be a great relief for the besieged. Bethell (1977), for instance, summarizes the dramatic course of events as follows. As early as in the middle of November the first ice was noticed on Lake Ladoga. During a mild winter, the ice does not form until January. On 17 November the ice was 10 cm thick, and on 19 November it was possible to drive small trucks on the ice that was now approximately 20 cm thick. On the next day, a group of horses with sleighs were taken from the western shore of Lake Ladoga to Kabona at the eastern side, and on 22 November 60 trucks crossed the lake. A mild period at the end of November (figure 13) temporarily stopped the traffic, although when the cold weather returned in early December it started up again. Approximately 400 3-tonne trucks drove from the western to the eastern side of the lake every day. Thanks to the cold weather it was possible to rescue numerous people from Leningrad and bring necessities from the rest of the USSR. It is generally held that this was the reason why the citizens of Leningrad were able to endure the siege the winter 1941–42. Steps were

TABLE 1. Morning temperatures at Leningrad and Moscow 07 local time for the winter 1941–42. (E. P. Borisenkov, pers. communication)

	Leningrad 1941–42						Moscow 1942		
Date	Nov	Dec	Jan	Feb	Mar	Date	Jan	Feb	Mar
1	−3.1	−4.1	−20.9	−13.8	−8.4	1	−26.8	−16.1	−22.5
2	−1.4	−5.2	−26.0	−13.2	−2.4	2	−28.0	−15.3	−7.8
3	−0.4	−4.6	−14.0	−18.4	−8.4	3	−35.9	−20.9	−4.4
4	−9.0	−10.6	−11.2	−15.2	−16.4	4	−27.2	−24.7	−13.7
5	−1.7	−14.5	0.0	−17.8	−23.0	5	−13.1	−23.9	−23.6
6	−9.7	−12.8	−12.0	−19.0	−14.0	6	−6.9	−24.5	−27.9
7	−5.9	−20.6	−8.6	−15.2	−13.7	7	−11.3	−19.3	−11.8
8	−3.4	−14.3	−19.8	−11.8	−14.3	8	−13.4	−14.9	−12.5
9	0.7	−14.2	−19.6	−10.0	−8.4	9	−9.1	−7.5	−10.6
10	−2.8	−15.0	−23.4	−9.3	−6.6	10	−10.2	−8.7	−5.5
11	−13.2	−12.4	−25.0	−9.4	−16.1	11	−15.1	−14.4	−2.9
12	−9.6	−14.1	−24.8	−10.4	−26.2	12	−25.8	−6.8	−15.3
13	−4.9	−17.0	−23.6	−16.7	−24.0	13	−30.6	−4.4	−10.7
14	−7.7	−18.0	−28.7	−8.4	−27.8	14	−23.9	−4.8	−16.4
15	0.2	−21.2	−12.2	−2.1	−21.9	15	−10.9	−15.9	−18.3
16	−0.4	−12.8	−12.6	−14.4	−27.3	16	−21.2	−20.1	−18.5
17	−2.5	−11.4	−15.8	−18.6	−21.0	17	−18.9	−17.1	−19.1
18	−8.3	−9.9	−16.0	−20.8	−28.3	18	−15.9	−19.5	−23.6
19	−13.2	−9.2	−20.0	−22.8	−18.2	19	−20.7	−20.8	−25.5
20	−5.8	−8.3	−27.1	−13.8	−24.7	20	−34.0	−15.3	−19.9
21	−3.8	−2.2	−29.3	−10.6	−15.8	21	−34.0	−7.5	−16.9
22	−5.8	1.2	−16.9	−15.2	−14.8	22	−22.3	−9.6	−11.1
23	−4.8	−2.6	−25.1	−13.4	−5.0	23	−31.2	−14.5	−11.6
24	−4.6	−15.4	−31.5	−9.0	−0.1	24	−31.8	−12.4	−4.0
25	−3.5	−15.1	−27.9	−20.6	0.2	25	−35.6	−1.4	−0.4
26	−3.3	−17.0	−21.3	−24.5	−0.6	26	−24.9	−10.1	0.8
27	−5.4	−20.8	−29.3	−20.0	−10.6	27	−31.0	−15.5	−3.2
28	−2.8	−19.3	−25.8	−17.4	−14.6	28	−30.8	−13.5	−9.7
29	1.2	−19.3	−14.6		−16.0	29	−14.9		−15.1
30	−1.4	−16.8	−10.0		−5.1	30	−16.9		−14.4
31		−18.2	−14.0		−14.2	31	−13.9		−7.2

taken to prepare for subsequent winters. The traffic did of course not go on without incidents. It is estimated that approximately 1000 trucks were lost because of holes in the ice and German bombs. The siege of Leningrad continued for almost two and a half years, finally ending on 27 January 1944.

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