

METEOCLIMATIC HAZARDS INDUCED BY THE EXPANSION OF THE SIBERIAN HIGH OVER EASTERN EUROPE. JANUARY 2010- A SYNOPTIC RETROSPECT.

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ABSTRACT. - **Meteoclimatic hazards induced by the expansion of the Siberian High over Eastern Europe. january 2010- a synoptic retrospect** This paper reviews the general characteristics of the thermal regime of January 2010 at global scale, underlining the role of the Asian (Siberian) winter High in the occurrence of the temperature and pressure anomalies in the Northern Hemisphere, in correlation with the Arctic Oscillation. Also the aero-synoptic structure is described accounting for the expansion of the Siberian ridge over most of Europe, with major implications on the severity of the thermal regime in much of the continent, including Romania.

Key words: Asiatic High, Arctic Oscillation, thermal anomalies, frosty weather

1. General considerations on the 2009-2010 winter

Throughout the 2009-2010 winter the weather patterns were influenced by a series of factors known for their influence on climate variability at planetary scale, such as the Arctic Oscillation and the North Atlantic Oscillation (in the Atlantic environment) but also El Niño and the Pacific Decadal Oscillation (in the Pacific environment). The novelty of the situation consisted in the simultaneity of the action of all these factors, fact that gave the 2009-2010 cold season a peculiar character, through which it affected the whole Northern Hemisphere, from America to Eastern Europe and farther to Mongolia and China.

Canada thus experienced its warmest winter in the history of meteorological measurements and the Arctic waters were uncommonly warm. On the other hand, the Arctic Oscillation being in a strongly negative phase (the AO index reached its lowest values in the last 60 years), initiated very cold pulsations towards southern latitudes, above Eurasia, where it triggered an extremely severe winter.

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El Niño for its part fuelled heavy storms with very large precipitation. Indeed, this combination of influences, exercised simultaneously by the Arctic Oscillation and El Niño to affect especially the US territory, had not been recorded since 1950. In New-York for instance, in February 2010 the abundant snowfalls caused the accumulation of a snow layer 93.7 cm deep, which set a new record (the ancient one was 77.47 cm, dating back from March 1896).

As regards Eurasia, the influence of the Arctic Oscillation was dominant. As a result, in England for instance, the winter of 2009-2010 was the coldest of the last 50 years.

2. Peculiarities of January 2010 at global scale

According to the National Climatic Data Center of NOAA, the first month of 2010 was ranked as the fourth warmest January since 1880. NASA's Goddard Institute for Space Studies ranks January 2010 as the second warmest, behind January 2007.

As regards the temperature of the planetary ocean, January 2010 ranked second after January 1998, whereas with respect to the ground temperature, the southern hemisphere set a new record, displaying the highest values in the observation series. Simultaneously, the Northern Hemisphere's January 2010 came only 18th in the string of the warmest Januaries, one of the reasons being the wider land surface but also the deep snow layer that month (the 6th deepest in the last 45 years).

On the other hand, measurements performed through satellite techniques show that the temperature in the first 8 km of the atmosphere ranks January 2010 as the warmest, according to the dataset of the University of Huntsville, Alabama (taken over by www.wunderground.com).

However, all these estimates are achieved at global level. As for Eurasia, conclusions differ. Thus, according to the British Met Office the United Kingdom as a whole experienced its coldest January since 1987 and the eighth coldest since 1914 (when coherent recordings have been initiated). Also, Scotland saw its coldest January since 1979.

Besides, on 2 January the centre of Beijing (China) was covered by a snow layer 8 cm deep, the thickest measured in one single day since January 1951, whereas in the outskirts of the capital city the depth of the snow layer was 33 cm. More than 50% of the flights from Beijing International Airport were cancelled and on 6 January the air temperature in the city dropped to -16.7°C, the lowest minimum in the first 10 days of January since January 1971 (according to the Beijing Climate Center, <http://bcc.cma.gov.cn/>).

In the Russian Federation, in Moscow, the mercury in the thermometers fell to -27°C, in Poland the red code for extreme temperatures was issued, and in

Romania around -35°C were recorded at Intorsura Buzaului (in the morning of 25 January) and -25°C in Bucharest (in the morning of 26 January).

In England, in deep snow layer circumstances, record temperatures of -21°C were reported (as the Daily Telegraph noted), whereas in Scandinavia, especially in northern Sweden, the temperature dropped on 8 January to -40.8°C (according to the BBC).

Bulgaria, instead, experienced spring-like temperatures at the beginning of January 2010: there were 14°C in Sofia and the temperature even reached 22.4°C at Veliko Târnovo. In that interval (the first 10-day period of the month), 18°C were recorded in Romania. In Crete, on 1 January the air maximum was 30°C , a new absolute January record for Europe. There results that overall the temperature at the level of the whole Northern Hemisphere was not lower than in previous years – quite the contrary, but the warmth was distributed unevenly.

A general estimation of the distribution of air temperature at the beginning of 2010, as well as of the positive or negative deviations recorded in January was performed by NASA with the help of satellite techniques.

As regards the Northern Hemisphere, strong negative anomalies were noticeable in Eurasia and south-eastern US, where the weather was much colder than normal, whereas in the Arctic, northern Europe and especially in Greenland positive deviations occurred at the beginning of 2010.

It is noteworthy that in Europe, the areas with the strongest and most persistent negative anomalies were the Romanian extra-Carpathian ones, with a further expansion in the whole Carpathian-Balkan sink, where the cold air advected from the Russian Plain easily penetrated by the sides of the Carpathian chain. The cold air mass could not escalate the northern frame of the mountain chain, because of its little vertical extension (a supercooled, dense, subsided mass) compared to the terrestrial relief, and it subsequently slipped latitudinally towards Central Europe.

On the other hand, the slightly positive temperature anomaly from the northern border of the continent rules out the hypothesis that cold air infiltrated from the Barents Sea by the sides of the Urals, as it often happens in the context of an intensely active East-European High. This means that the very severe thermal regime that caused the weather to be extremely frosty in that period (the last 10 days of January 2010) in Eastern and Central Europe was totally due to the expansion of the Asian High ridge west of the Urals, which caused the penetration of the Polar continental air, initially of Arctic and, further continentalized, Siberian origin, over the European continent.

3. General characterization of the Siberian (winter-Asian) High

This anticyclone is a semipermanent high pressure centre acting over the Asian continent (North-Eastern Siberia / Central Siberia / Mongolia) during the

cold half of the year. One of the main factors contributing to its formation is the intense cooling of the air layers in the vicinity of the ground during the mentioned cold season, the Asian High being in fact the main source for the formation of continental Polar air masses (Fig. 1).

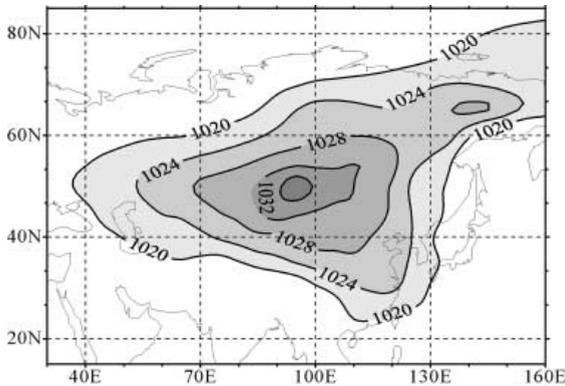


Figure 1. Mean pressure at ground level above Asia in the cold season, averaged over the 1961 through 1990 interval, illustrating the persistency of the winter Asian (Siberian) High (after Trenberth and Paolino, 1980).

Its vertical expansion is rather small, rarely exceeding 3000 m (which makes it irretrievable on the absolute pressure topography maps for the level of 500 hPa), because of the supercooling of the constituting air volume, which causes it to subside, unlike the anticyclones from the tropical high pressure belt, warm anticyclones that are remarkably well developed in the vertical, as they are made up of air masses of tropical origin, heavily warmed up by the intense solar radiation in the tropics.

The Asian High is characterized by very low temperature values in the constituting air mass, often under -40°C in its central area, where the air pressure frequently exceeds 1035 hPa (Fig. 3), often even 1040 hPa, thus being the strongest semipermanent pressure centre of the Northern Hemisphere, accounting for the absolute low temperature record (the “pole of hard frost” in the Northern Hemisphere is considered to be situated in eastern Siberia, in Verhoiansk (-68.9°C on 7 February 1892) – Oimiakon (-71.2°C on 26 January 1926) area. In the same context of the seasonal activity of this pressure centre the highest ever recorded pressure value of 1083.3 hPa was read at Agata, in Siberia, on 31 December 1968.

The forming mechanism of this semipermanent, yet extremely intense, anticyclone, as well as its corresponding structure in the altitude, presented in detail in the specialized literature (Ecaterina Bordei-Ion, 1983) does not require additional detailing. In the context of this paper the anticyclone’s pulsations towards the regions west of the Urals are worth of interest.

Thus, as regards the expansion of this atmospheric action centre towards Europe and its influence on the weather developments, the position of the Asian High in markedly eastern coordinates (Siberia, Mongolia) and its scanty vertical development only rarely allow it to penetrate over the European continent (Panagiopoulos, F. et al, 2005) and in such situations the expansion takes place mostly from its south-western border.

In those cases, a south-easterly circulation is directed towards Romania from the subtropical or semi-desert geographic areas, over the Caspian Sea, the Caucasus, the Black Sea, the Asia Minor peninsula, the Aegean Sea and the Balkan Peninsula. This circulation obviously sets in motion rather warm air masses, therefore, unable to cause the frosts regularly attributed to this pressure centre, frosts that are the most often determined, in fact, by the action of the East-European High, dominating in winter over north-eastern Europe and which is born through formative mechanisms other than those accounting for the Siberian High, with a well shaped individuality, as shown by the specialized literature (Ecaterina Bordei-Ion, 1983).

There are, however, situations, though ever rarer in the last decades in the context of global warming, when the cold air accumulation within the Asian High mass becomes significant enough to occupy almost the whole surface of the Asian continent and to overflow the Ural Mountains chain with the highest peak Poznurr, at 1895 m.a.s.l. in the Narodnaia massif), or at least its central, middle part, with the lowest elevation (under 1000 m.a.s.l.), to then further expand as a supercooled Polar continental air mass over the vast open areas of the East European Plain, causing brutal and long lasting air cooling in every invaded territory, Romania included.

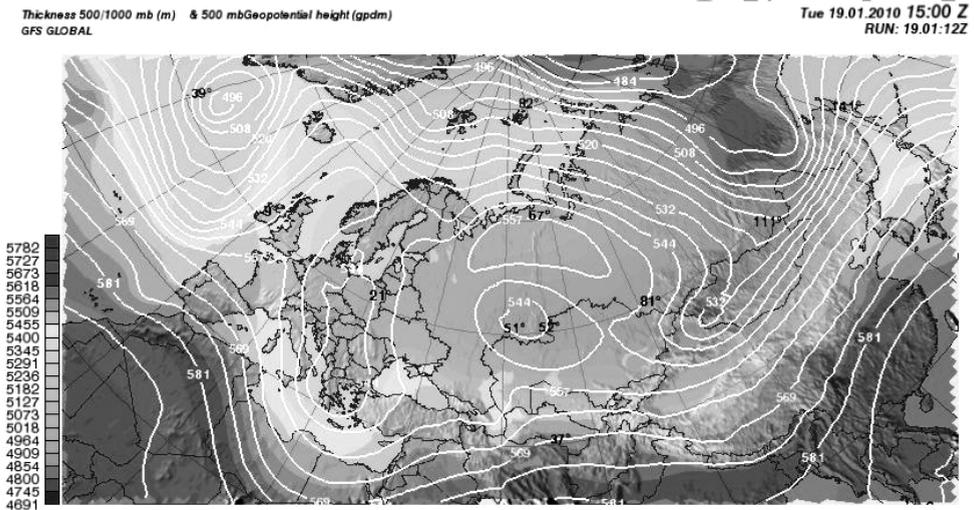
Such an example is the particularly frosty episode from the last 10-day period of January 2010, when Moscow recorded temperatures of -27°C , Poland issued a red code for low temperatures lasting three consecutive days and in Romania thermal values were up to 20°C lower than the multiannual means of the interval.

4. Analysis of the general arosynoptic configuration

It seems that the main factor to be held accountable for the thermal differences between the various areas of the Northern Hemisphere, as rendered at the beginning of this paper, is the so-called Arctic Oscillation (AO), – the (sea level) pressure difference between the Arctic and the mean latitudes (the Mediterranean in the case of Europe).

At the beginning of January 2010, AO was in a markedly negative (cold) phase, caused by pressure values higher than normal above the Polar regions and lower pressure values above the mean latitudes. As a result, the zonal (east-west) circulation was weak, as was the jet stream, which favoured a meridional (north-south) circulation and led to strong penetrations of the cold Polar air towards the mean latitudes. The high pressure from above the Polar regions actually forced the cold air to descend towards more southerly latitudes and the weak jet stream implicitly displayed large winding flows. These resulted in a cold and windy

weather in most of Europe, Northern America and Eurasia, since it is known that when the jet stream is strong its undulations are less ample, its flow is straighter and the Arctic air does not penetrate very far south. On the contrary, when the jet stream is weaker, it has more ample undulations and its marked deviations southwards allow the Arctic air to reach in regions with a normally warmer climate. In such a situation, the very cold Arctic air penetrated from the Arctic over north-eastern Asia, further piling up at lower latitudes and stabilizing over the deep pre-existing snow layer, as the geopotential field in the altitude ascertained the presence of a trough structure, typical for the cold anticyclones with a scanty vertical development proceeding from the Polar ice cap (Fig. 2).



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Figure 2. Air temperature distribution in the 1000-500 hPa layer and the geopotential at 500 hPa on 19 January 2010 (after www.meteoblue.com – GFS model).

As the air layers in the vicinity of the ground grew supercooled, this air mass became very stable, expanded over much of the Siberian Asia and became a vast Asian High, with a central pressure in excess of 1060 hPa towards the end of the second 10-day period of January 2010 (Fig. 3).

Additionally and continually fuelled from the ice cap, this anticyclone advanced towards Western Asia and fragmented. The supercooled Polar continental air mass overflowed the Urals towards the East European Plain, unfolding afterwards (21 January 2010) over the east of the European continent (Fig. 4).

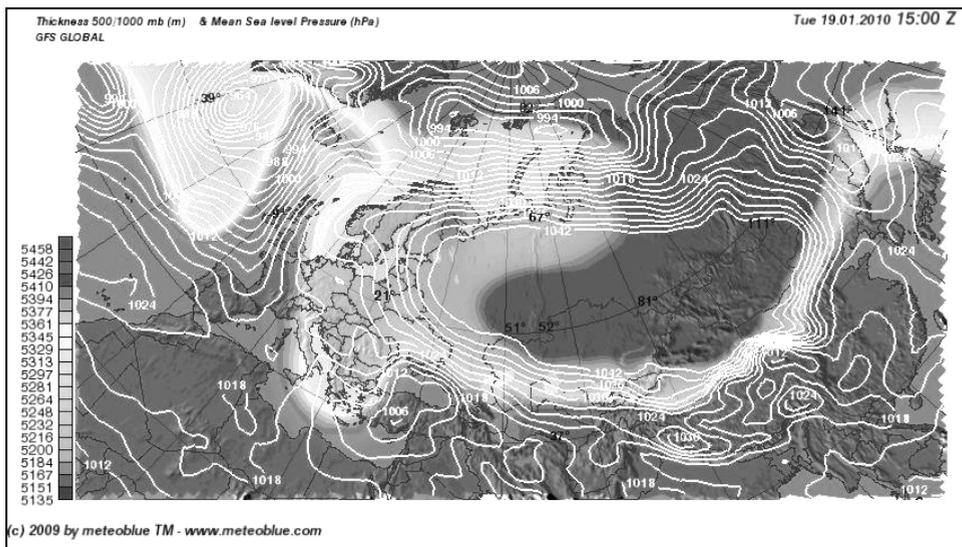


Figure 3. Ground level pressure and air temperature distribution in the 1000-500 hPa layer on 19 January 2010 (after www.meteoblue.com – GFS model).

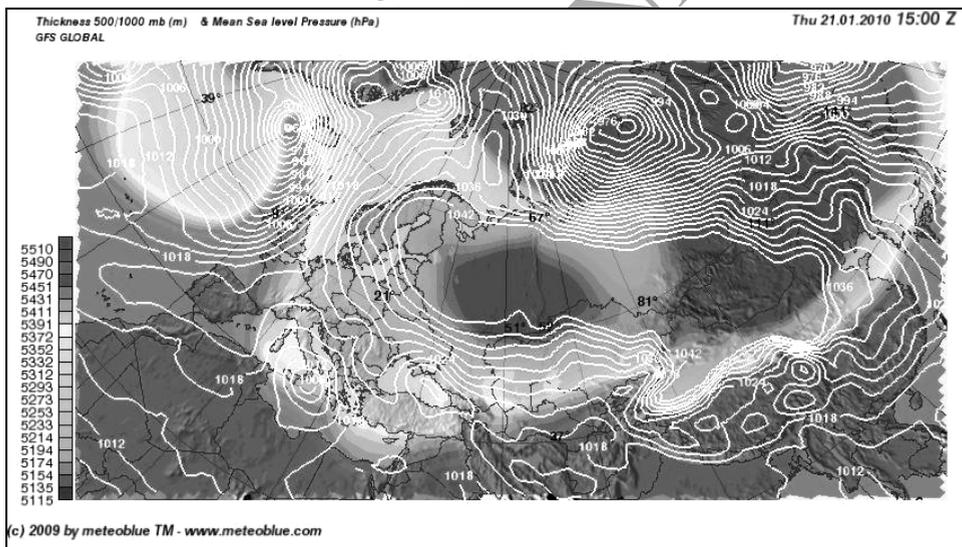


Figure 4. Ground level pressure and air temperature distribution in the 1000-500 hPa layer on 21 January 2010 (after www.meteoblue.com – GFS model).

Under these circumstances, the air pressure was very high in Siberia within this Asian High and air temperatures were very low in the anticyclonic mass, e.g. maxima of -34°C and minima of -40°C at Tomsk, in the south-west of Asian Russia (north of Novosibirsk) (Fig. 5).

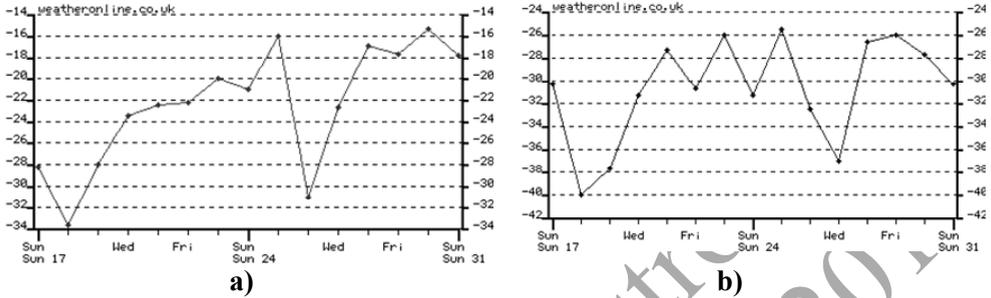


Figure 5. Graph with maximum (a) and minimum (b) temperatures recorded from 17 to 31 January 2010 at Tomsk (Russia, Asia) (after www.weatheronline.com).

Such low temperature values were recorded as a snow layer as deep as 75 cm was laying on the ground in high pressure circumstances (up to 1055 hPa, which speaks for itself about the intensity of the monitored anticyclone).

The subsequent evolution of the anticyclonic ridge of Siberian origin having reached ground level above eastern Europe discloses its expanding trend towards the north, centre and south-east Europe, engulfing the geographic environment of Romania also. As can be seen, having reached the continent, the Asian High induces an eastern-north-eastern circulation in our country on 22 January, with a significant share of cold air mass. However, as the high pressure structure also advances towards the Scandinavian Peninsula, where it will further centre itself, the prevailing easterly circulation begins to concern the central-western countries of Europe and finally the south-western ones and the weather becomes significantly colder over much of the continent. The advance of this high pressure structure over the European continent, accounted for by the evolution of the air pressure, caused the weather to get markedly colder, as results from the graphs rendering the course of the air temperature and pressure in some European cities (Figs. 6, 7 and 8).

As it got supercooled at its base, the high pressure ridge was not significantly thick but rather lenticular, expanded horizontally, which is typical to the cold anticyclones of Polar origin. That is also why during this thermally severe episode, in Romania the air mass had an east-Pericarpethian infiltration especially during 20 January, causing the temperature to decrease by up to $10...11^{\circ}\text{C}$ from day to day, as illustrated by the difference between the minimum temperatures recorded in the mornings of 20 and 21 January respectively (Fig. 9).

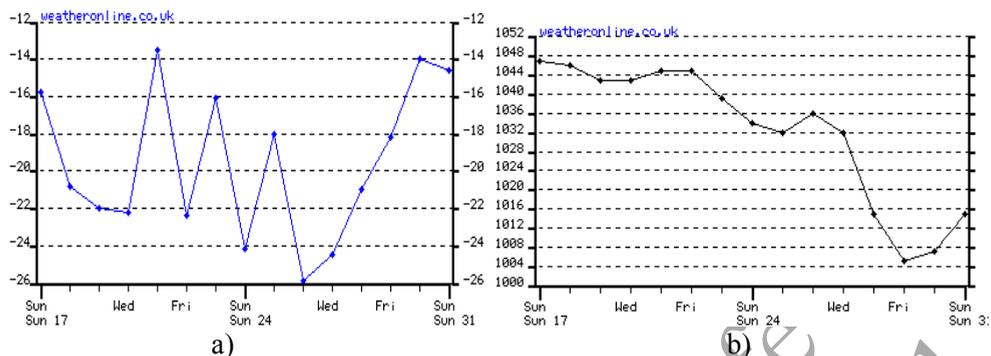


Figure 6. Graph of mean temperature as °C (a) and ground pressure as hPa (b) recorded from 17 to 31 January 2010 in Moscow (according to www.weatheronline.com).

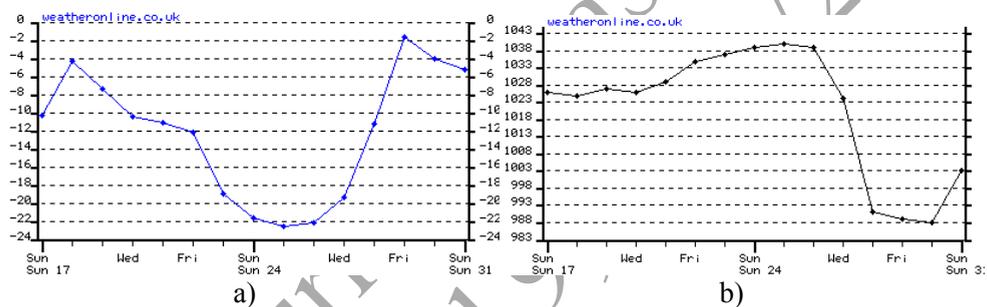


Figure 7. Graph of mean temperature as °C (a) and ground pressure as hPa (b) recorded from 17 to 31 January 2010 in Warsaw (according to www.weatheronline.com).

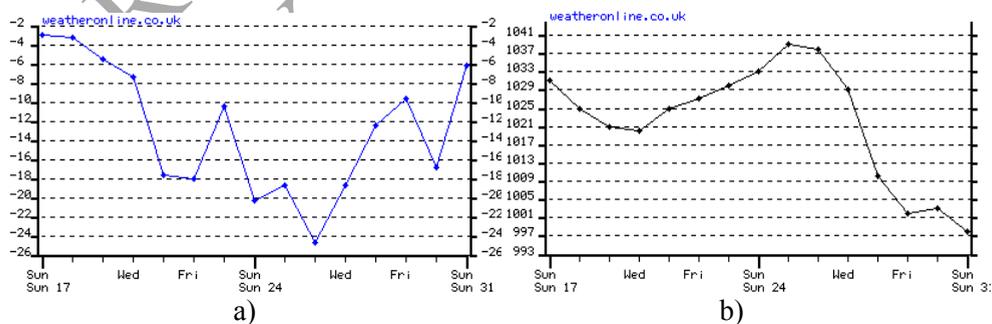


Figure 8. Graph of mean temperature as °C (a) and ground pressure as hPa (b) recorded from 17 to 31 January 2010 in Bucharest (according to www.weatheronline.com).

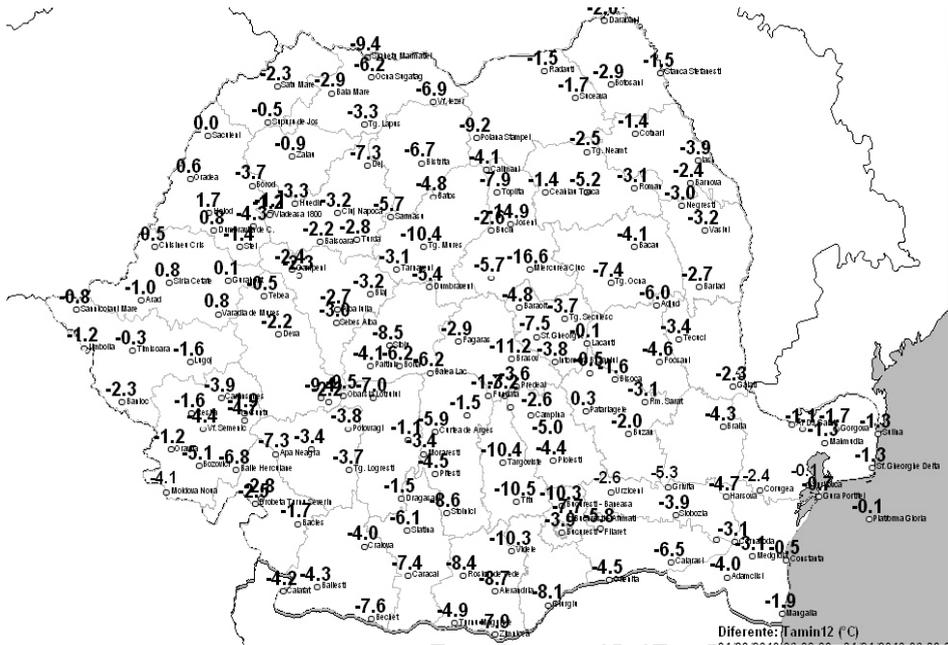


Figure 9. Difference (as °C) between the minimum temperatures of 21 January and those of 20 January, illustrating the east-Pericarpathian cold advection (NMA data).

During this frosty weather episode the temperature in our country dropped to -34.8°C , recorded in the morning of 25 January at Intorsura Buzaului (Fig. 10), which was only 3.3°C higher than the absolute all-country minimum value ever recorded, -38.5°C , a reading from Bod locality, in Brasov County, again on a 25 January, but in 1942. However, as the very cold Polar continental air expanded over the Balkan Peninsula and stabilized, the very severe thermal regime became characteristic to the plain regions in southern Romania too; thus, one day later, on 26 January the minimum temperature recorded in Bucharest was -24.5°C at the Filaret weather station and -24.8°C at the Baneasa weather station. Overall, in the 21-28 January interval there were recorded temperature values $15\text{...}20^{\circ}\text{C}$ lower than the multiannual means of the period.

Conclusions

Although less and less frequently, situations still occur when the ridge of the Siberian (Asian) High penetrates over the European continent not only by expanding towards south-western Asia and further heading over south-eastern Europe but also by escalating the rather eroded Ural Mountains (less than 2000 m

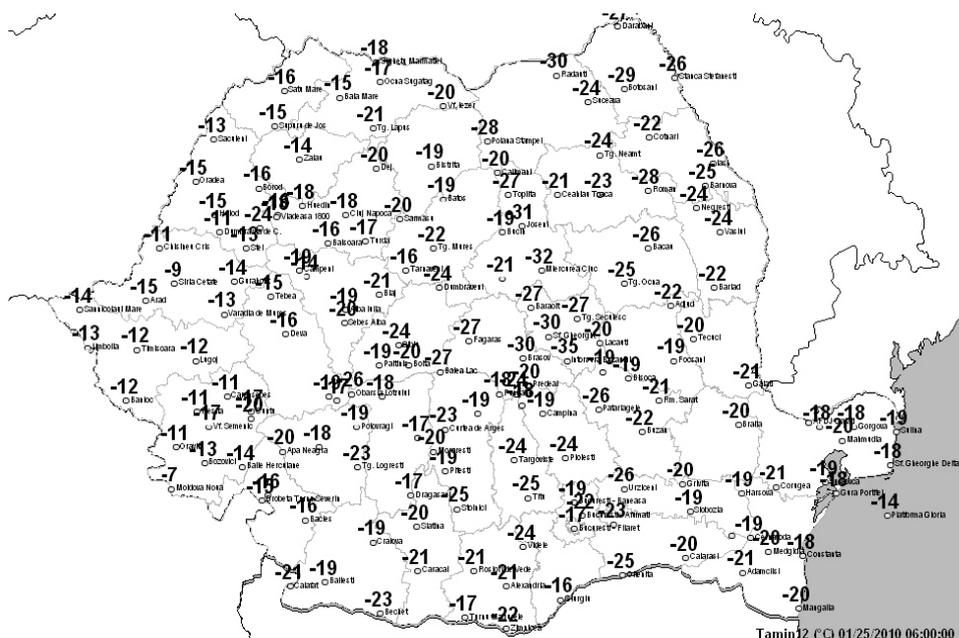


Figure 10. Minimum temperatures recorded in Romania on 25 January 2010 (NMA data).

high), especially in their central section, where the altitude is low. This happens, as this paper has described, when the mass accumulation through the intake of Arctic air over Siberia and the air density increase through supercooling reach a balance, which allows the increase in depth of the huge lenticular pellicle of cold air this anticyclone identifies with during it building up, to sizes comparable to the heights of the mentioned section of the mountain chain of concern.

In situations like this, there is no such thing as the motion of air masses from subtropical geographical areas, as in the case of the south-west Asian - south-east European trajectories, because the initial, excessive Polar continental, character of the air plays a major role in the brutal drop of the thermal regime in the geographic areas it occupies.

To conclude with, although the Arctic air of direct northern origin, most often constituted into an East European (Asian) or Scandinavian High is accountable for the frosts in Europe, it is however stringent to perform extended monitoring at the level of the whole northern hemisphere as regards the air circulation, so as to correctly identify the advection directions, in order to give an accurate interpretation to the genetic causes of the cold waves.

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