MAJOR WINTER-INDUCED THERMAL RISKS IN THE ALBA IULIA – TURDA DEPRESSION

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Abstract. The present study deals with situations created by negative temperatures, the formation of these temperatures and their average and maximum frequency, as well as their occurrence at times other than the specific period. The impact of these phenomena on the economy, basically on the range of crops extended over large areas in the Alba Iulia – Turda Depression, is discussed.

Key words: cold waves, absolute minimum temperatures, frosty nights, winter days, freezing days.

1. Introduction.

Negative, sometimes extremely low temperatures represent climate risk phenomena which can affect people's health and imperil economic activities. The paper discusses the main thermal risks in winter, such as cold waves, absolute minimum temperatures, average and maximum frequency of specific winter days, or their occurrence outside the characteristic interval, which may sometimes be registered even in this region governed by well-known Föehn effects.

2. Waves of cold polar or arctic air and absolute minimum temperatures.

Cold waves designate the cooling of air, or the advection of a very cold air over vast temperate regions. Cold waves are usually generated by arctic air, occasionally also by continental polar air of East-European origin (Ţâştea et al., 1965).

Cold waves entrain negative thermal extremes that may seriously impair people's health, affect society and the environment, generally. A knowledge of the limits and occurrence conditions of extremely low temperatures is of great practical importance because of their negative economic impact on agriculture, forestry, constructions, transport, tourism and human health.

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The way in which pressure centres, which govern the movement of the masses of air, as well as the frequency and intensity of cooling processes, determine the penetration of waves of frosty dry air in Romania, producing strong negative thermal deviations from the normal regime (Bogdan, Niculescu, 1999).

The occurrence of very low temperatures is favoured by the following directions of the atmospheric circulation:

– north-west (polar), manifest against the background of an extended Azore Anticyclone over Western Europe simultaneously with a vast depression in the East of the Continent. This circulation carries the cold polar air to the south-east of Europe;

– north (along the meridian), manifest in the conditions of a cyclonic regime, extended throughout Eastern Europe, and of the NNE expansion of the Azore Anticyclone ridge to the south of the Scandinavian Peninsula, ushering in a cold air advection on the front edge of the ridge;

– typically north-east (ultra-polar), which occurs when the ridge of the East-European Anticyclone extends farther to the south-west associated with an active cyclonic regime in the eastern Mediterranean region, the Balkan Peninsula and the Black Sea.

Therefore, cold waves are carried by a polar, but mostly arctic continental air through the intermediary of the Greenland, Scandinavian and East-European anticyclones, seldom the Siberian Anticyclone, all these high pressures determining advective coolings. The presence of an Anticyclonic regime in the southern half of the Continent, with persistent clear skies and calm, favours the development of radiative cooling.

Steep temperature falls are determined by massive advections of arctic or polar continental air combined with intense radiative coolings generated by the presence of strong anticyclones, in which case the air accumulates in the lower parts of the relief, creating thermal inversions and a stable favouring snow cover stability (Ciulache, 1999).

Peak cooling intensity occurred whenever minimum temperatures dropped below -30°C, but usually thermal means stood under -10°C. The lowest proportion of massive coolings (as they have been named) is found in the centre of Romania (28.6%), comparatively with the regions lying on either side of the Carpathian Chain, due to the shelter offered by the Eastern Carpathians against the cold air advections from the east or north-east, whereas intracarpathian regions are exposed to advections from the north, or north-vest of the Continent (Bogdan, 1998; Bogdan, Niculescu, 1999).

Sharp coolings (absolute minima ≤ -30°C) are caused by a cold arctic air hovering over the lowlands alongside the Mureş and the Olt corridors of the Transylvanian Depression, and by radiation in the conditions of a high pressure regime.

Negative thermal extremes associated with waves of cold represent a climate risk which sometimes affects the Alba Iulia – Turda Depression since the Mureş Corridor favours the cold air to station at the bottom of the valley. Massive January coolings of -30°C (basically absolute 20th century minima) were recorded at all the five weather stations located in the study area: Sebeş, on the 24th 1963 (-33.9°C), Ighiu (-32.4°C) and Blaj (-32.1°C); on the 25th 1942 at Turda (-31.6°C); on the 14th 1985 at Aiud (-31.0°C) and on the 31st 1947 at Alba Iulia (-31.0°C).

In 1963 and 1942, record high massive cooling registered many of Romania's regions (Bogdan, Niculescu, 1999).

January 1942 was the frostiest 20th-century month, generated by the arctic air advections carried by the intense activity of the Scandinavian and East-European Anticyclones, correlated with the Mediterranean and Pontic cyclones, and bringing about heavy snowfalls. Under these conditions of radiation-induced cooling influenced also by the snowpack, minimum temperatures fell under -25°C throughout the country on the 23rd, 24th and 25th, basically an absolute minimum registered by 26 stations. Climate risks were due to a combination of negative temperatures with frost and high snowpack humidity. Severe frost added to people's already difficult life caused by the Second World War. Also, fruit productions that year were reduced because young tree branches had nipped in the bud.

Between the 18th and the 25th of ***January 1963***, absolute minima were registered by numerous weather stations in Romania. Massive cooling was brought in by polar continental advections from northern Europe combined with the persistence of anticyclonic weather. The synoptic situation revealed the expansion on the ground of a high pressure field over Europe and the presence of a very cold air nucleus in the air, positioned mainly over Romania (fig. 1, 2).

The negative impact of these extremes on agriculture was the greater the severer freezing phenomena were.

3. Winter days and their thermal characteristics.

Another useful variable to gage the intensity of cooling and its detrimental effects is the frequency of days with negative thermal characteristics: frosty nights, winter days and freezing days.

Frosty nights occur whenever the minimum temperature is under -10°C. In the study region, values ≤ -10°C are seldom recorded, all in all, less than 20 days/year. However, there were years when 37 and 42 days (Sebeş and Ighiu stations, respectively) did occur (Fig. 3).

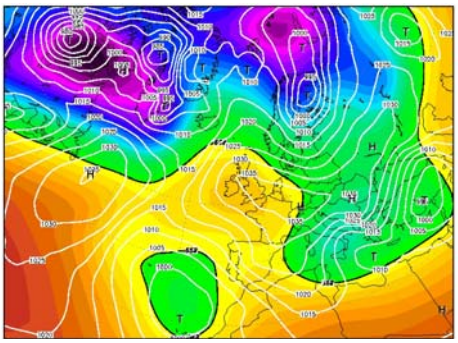

Fig. 1, Atmospheric pressure field on the ground and a geopotential field at 500 hPa (5,500 m) January 24, 1963, 00 hr GMT (source: Karlsruhe Weather Centre Archive, Germany).

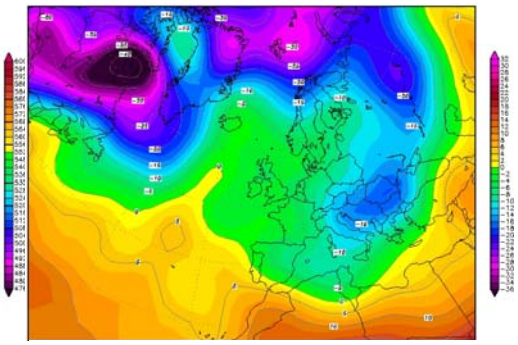

Fig. 2, Temperature (°C) at 850 hPa (1,500 m) January 24, 1963, 00 hr GMT (source: Karlsruhe Weather Centre Archive, Germany).

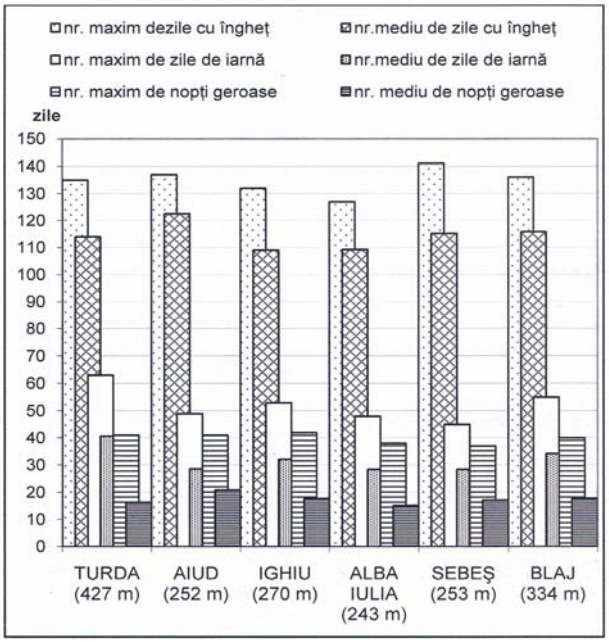

Fig. 3, Annual average and maximum number of winter temperature days.

Frosty nights *over the year* are usually recorded between November and March, the monthly average number of nights (6-9) with maximum negative temperatures is registered in January, the coldest month of the year; such nights

have the lowest average incidence in November (0-1) and March (1-2) (fig. 4), that is at the beginning and end of the cold season, respectively.

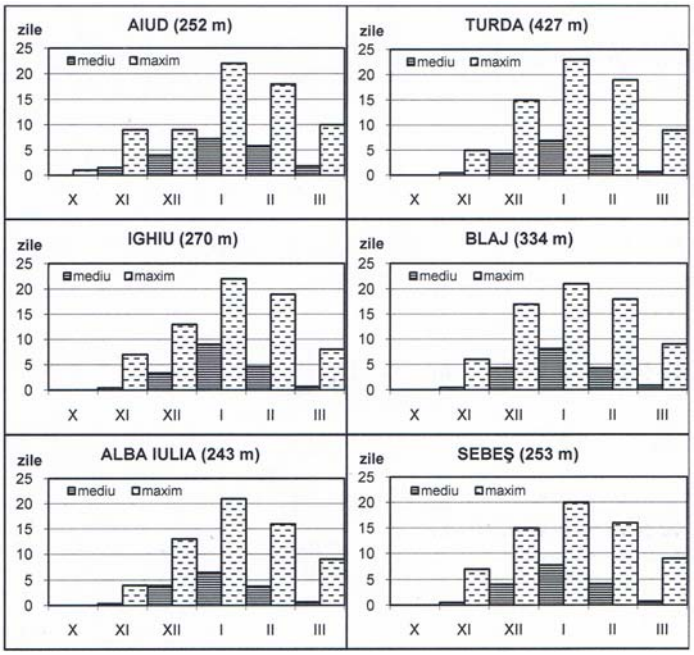

Fig. 4, Monthly average and maximum number of frosty nights.

The monthly maximum number of frosty January nights over the analysed period was two-three times higher than the monthly averages, totalling 20-23 days in the months of January, which were the coldest throughout the period studied. However, highest deviations from this average are recorded in November and March (when winter sets in very early or very late), up to 9 and 10 frosty nights, respectively specifically in January. In 1988, a frosty night was registered at Aiud as early as the 27th of October.

Whenever such significant coolings, characteristic of wintertime, take place during the transition seasons, they produce late freezing in spring and early freezing in autumn, putting crops in jeopardy. In the absence of a protective snow cover, frost-induced damage reduces wheat crops in autumn.

Winter days occur whenever the thermal maximum falls below 0°C. Every year there are 30-40 winter days on *average*, the highest record having Turda station (41 days/year) which, lying at 427 m a.s.l. is more exposed to the cold advections from the north and north-west than the other five stations (only 28-32 days/year). *The annual maximum number* of days: 45 at Sebeş, 53 at Ighiu and even 63 at Turda (fig. 3).

Winter days are registered from November through to March with the exception of Turda, where a winter day was found in October 1985 (fig. 5).

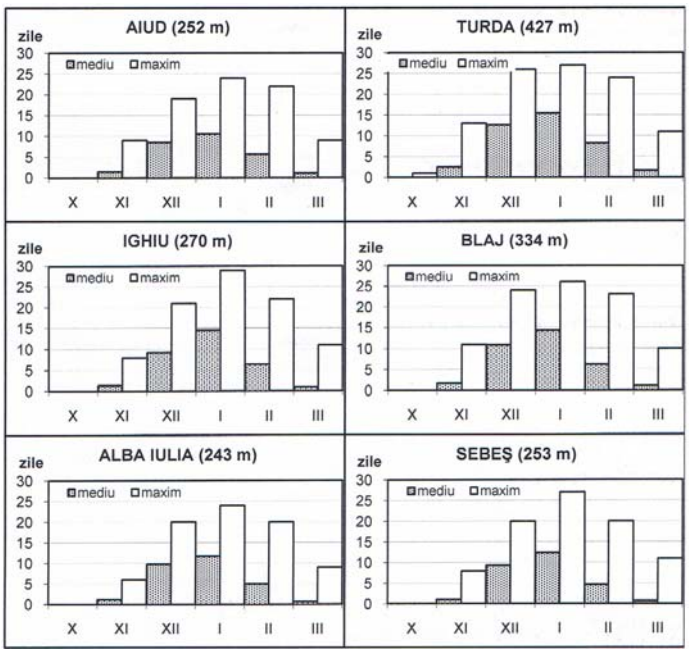

Fig. 5, Monthly average and maximum number of winter days.

Winter days are characteristic of the winter season, with highest monthly averages (11-16 days) in January, the values increasing directly proportional to altitude: 11-12 days at Aiud, Alba Iulia, Sebeş, and 16 at Turda; 5-8 days in February and only 1-2 days in November and March (fig. 5).

Monthly maxima: 24-29 days, in January, 20-26 in December and February, 11 and 13 days in March and November, close to the January means, as well as the one case at Turda in October 1985 point to the vulnerability of this region exposed to climate risk in the transition seasons (fig. 5).

Freezing days feature minimum temperatures lower or equal to 0°C, and they number between 110 and 120 days/year on *average* at all the stations situated in the Alba Iulia-Turda Depression. However, there were years when a higher number of maximum days/year was registered at Sebeş Station which lies at the convergence of two broad valleys (the Mureş and the Sebeş), a geographical position that poses a greater risk of cold advections coming from the west and the east, respectively (fig. 3).

Freezing days average seven months/year from October to April. However, quite exceptional by 1-2, or even 2-3 such days occurred in September (fig. 6), caused by fluctuations in the general atmospheric circulation.

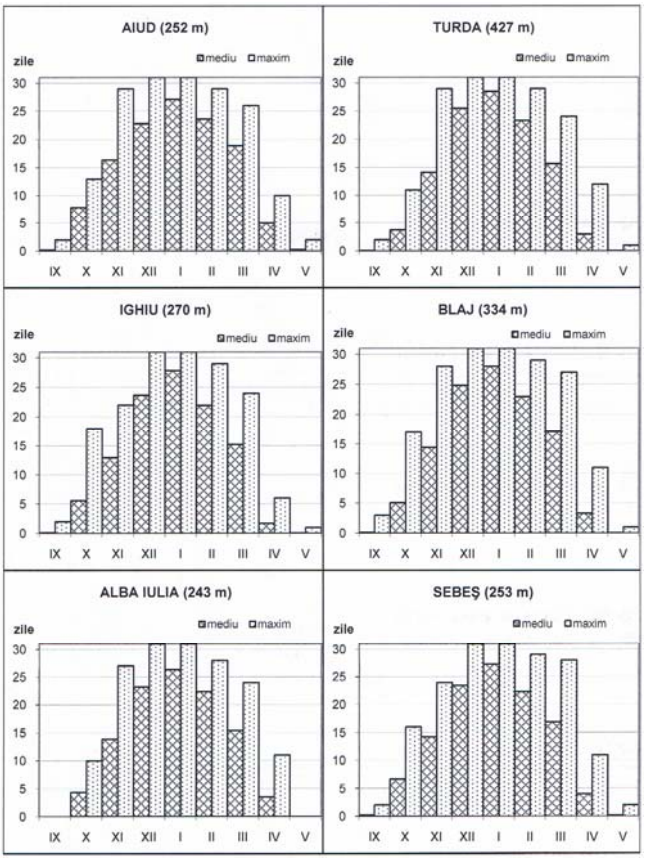

Fig. 6, Monthly average and maximum number of freezing days.

The monthly average number of freezing days is reached in January, when cooling processes are at their height: 27-29 days compared to 23-26 in December and 22-24 in February; 15-19 in March, 13-14 in November, and seldom more than 6 or 4 in October and April, respectively. Noteworthy, early freezing in October is usually recorded at Sebeş Station, also because the cold air, cooled at higher altitudes, is channelled into the Sebeş Corridor (fig. 6).

The monthly maximum number of freezing days registered in certain years, depended on the December and January temperatures registered at all the stations. February and November also totalled up to 29 days: 27-28 at Blaj and Sebeş, where values fell below 0°C even in March. At the beginning and end of the freezing

interval, Blaj, Ighiu and Sebeş stations registered 15 freezing days in October and over 10 days in April, almost at all the stations (fig. 6).

Early freezing in autumn (October or September even) and late Spring frost (April and May) represent climate risk phenomena incurring much damage to plants, diminishing wheat crops by damaging autumn sowing, and jeopardising the annual production of fruit and grape by nipping the buds in spring.

4. The impact of negative temperatures on crops.

Farmers and botanists have long been observing how the air temperature influences the vegetation stages and the thermal limits for culture plants to develop (Berbecel şi colab., 1970).

The thermal requirements of culture plants in Alba Iulia–Turda Depression depend on their areas of origin. For example thermophile species of tropical and sub-tropical origin need a minimum temperature of 8-12°C for seeds to germinate, elevated temperature means of over 20°C in the period of growth and accumulation of substance (22°C for maize, sun-flower, pepper, tomato, beans, etc., 25°C for cucumber, pumpkin, the egg plant, etc.). Frosty weather is detrimental to these species.

Species coming from the Mediterranean and temperate zones require lower germination temperatures (1-6°C), optimal mean values under 20°C during growth and accumulation of substance: 13°C for cabbage, turnip cabbage, cauliflower, radish, horse radish and barley; 16°C for wheat pea, spinach, salad, carrot and parsley; 19°C for onion, beet, celery, etc. The minimum temperature these species can cope with are -2°, -3°C (Dragomirescu, Enache, 1998).

The phenological data show clearly that the optimal seed germination temperature for culture plants in the Depression usually starts on the 1st of April (Mărculeţ, Mărculeţ, 2009). However, when warm periods are frequently occurring before that date, plants would sprout earlier, fruit-trees would blossom, wine buds open, and there is a greater risk for negative temperatures (frost) and hoar to set in.

Under normal conditions, late frosts and hoar represent climate risks only if they occur after the 1st of April. Over the 1961-2003 period, such situations were recorded on April 4-7, 1970; April 10-16, 1995, April 6-10, 1997, etc. (Table 1), when temperatures fell below -4°C; these were basically cases of severe frosts (Dragomirescu, Enache, 1998).

Early autumn frosts, before the first decade of October, prevent grapes, corn and some vegetables from maturing and ripening, depleting the quality and quantity of these crops.

Table 1. Severe late frosts in Alba Iulia–Turda Depression

Station	Occurrence interval	Temperature value and occurrence date
Turda	4-6 IV 1970 6-10 IV 1997	-5.0°C la 5 IV -4.3°C la 9 IV
Aiud	11-17 IV 1988 10-16 IV 1995 8-10 IV 1997	-4.3°C la 17 IV -5.0°C la 11 IV -4.2°C la 9 IV
Alba Iulia	10-13 IV 1995 6-10 IV 1997	-4.8°C la 12 IV -5.5°C la 9 IV
Sebeş	2 IV 1965 11-12 IV 1968 8-11 IV 1969 5-7 IV 1970 16-17 IV 1971 2-7 IV 1974 9-16 IV 1995 6-10 IV 1997 10 IV 2000	-4.1°C -4.6°C la 12 IV -4.3°C la 10 IV -4.6 °C la 5 IV -4.4 °Cl a 16 IV -5.1°C la 3 IV -6.3°C la 12 IV -5.8°C la 9 IV -4.0°C

Negative temperatures (below -20°C) in wintertime are highly damaging for the uncovered autumn wheat, for vine if not buried, and for fruit-trees (pear, plum, apricot and peach). Buds, tendons and young shoots are freezing. Such temperatures were recorded for 56 days at Sebeş and 22 days at Turda throughout the study period (1961-2000). Most such cases were recorded in January – 41 days at Sebeş and 19 days at Turda, the frequency total being 3.3% at Sebeş and 1.7% at Turda. Such very low temperatures may be seen also in March (2 days at Sebeş) (Mărculeţ, Mărculeţ, 2010). Values blow -24.5° …-27.0°C were registered in January 14-15, 1980; 12-14, 1985 -21.0° …-27.6°C; 6-9, 1990 -20.5° …-23.7°C; February 1-2,1996: -20.2° …-21.2°C, and March 5-8, 1987 -20.2 …-21.4°C.

In conclusion, different types of crops extending over various areas in the Alba Iulia – Turda Depression, are often exposed to severe risks of freezing during the vegetation period that may compromise productions.

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