LATE SNOWFALL AND BLIZZARDS IN MOLDAVIA. APRIL 2017 SUMMARY CASE OF STUDY

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ABSTRACT. – Late snowfall and blizzards in Moldavia. April 2017 summary case of study. While these are normal phenomena for Romania's geographical position, heavy snows and intense blizzards can have severely negative effects, especially when they occur unseasonably, before or after the typical period. The blizzard recorded on 19-20 April 2017 was particularly violent and one of the latest blizzard events in the history of meteorological observations. In comparison, the last significant late winter event, albeit lower in intensity, was recorded on 15-16 April 1996. However, the blizzard formation mechanism in the month of April in eastern regions is relatively similar. The presence of a high-pressure zone in the central-western European region led, in both cases, to fast large-scale penetrations of arctic air from high latitudes towards areas with high cyclogenetic potential in the Mediterranean Sea basin. Thus, the depressions of Mediterranean origin, which formed in the Genova Gulf area, advanced towards the Black Sea basin via trans-Balkan trajectories, where they regenerated and resulted in strong wind intensification and abundant precipitation in the Moldavian region. With regard to the event this study analyses, the high thermobaric contrast and the presence of a sufficiently cold air mass favored, during the night between the 19th and the 20th of April, the occurrence of a strong blizzard event in Moldavia, following abundant wet snowfall during the day. At several meteorological stations across Moldavia and Transylvania, as well as in mountainous areas, the maximum winter snow layer thickness was exceeded on the 20th and 21st of April.

Keywords: blizzard, wet snow, severe cooling, aggravating factors, late snow.

1. INTRODUCTION

The most complex wintertime risk phenomena are blizzards. In Romania, they were thoroughly studied by several researchers, such as Șorodoc (1962), Bălescu and Beșleagă (1962), Bordei Ion-Ecaterina and Nicolae (1983), Ciulache and Ionac (1995), Ciurlău and Sașu (2014). These studies presented various facets of blizzard events recorded in Romania, including those that occurred outside the typical period. While the country's most vulnerable region in terms of blizzards is the southeast, high-intensity events can also occur in Moldavia due to the presence of a high-pressure zone centered in western or north-western Europe, coupled with the movement of a Mediterranean cyclone that regenerates in the Black Sea basin, often associated with a

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slightly retrograde propagation. Blizzards can have severe negative consequences when they occur synchronously with other factors such as the formation of wet snow, which subsequently freezes onto various objects, trees and electrical cables, glazed frost and ice that favor snow transportation, and phenomenon occurrence outside the typical climatological period. Snow that contains a large amount of water in liquid state is defined as wet snow (Glickman, 2000). Usually, wet snow deposits form during snowfalls that occur at temperatures ranging from 0 to 3 C, but such instances have also been documented at slightly negative temperatures (Sakamoto, 2000). Under favorable temperature conditions, an intense, long-lasting snowfall will result in considerable deposits on electrical cables and trees of up to dozens of N/m (Makkonen și Wichura, 2010). The 19-21 April 2017 event was chosen due to several reasons. Its occurrence far beyond the normal period, the abundant wet snowfall and the blizzard recorded during the night between the 20th and the 21st of April all led to consequences that were much more severe than those of a regular wintertime event. This had distinctive consequences.

2. METHODOLOGY

The synoptic and mesoscale analysis of the blizzard event of 19-20 April 2017 entailed the use of several types of maps: mean sea-level pressure maps, temperature, wind direction and speed, geopotential (300, 500, 850, 1000 hPa), which were obtained from the Eumetrain platform and processed using the outputs of the ECMWF (European Centre for Medium-Range Weather Forecasts) global numerical prediction model. With the mesoscale analysis, we also interpreted data provided by the National Meteorological Administration's (A.N.M.) weather station network, outcomes and analyses of limited-area numerical prediction models of A.N.M. (ALARO) and hourly ground maps in order to determine the cyclone's development on Romanian territory. Moreover, NOAA reanalysis maps and the NCEP/NCAR database were used for the long-term analysis. Additionally, the A.N.M. daily weather recordings archive for the month of April was analysed by the study's authors

3. RESULTS AND DISCUSSIONS

3.1. Preceding conditions (16-18 April 2017)

On a European scale, preceding conditions consisted of the expansion of a long-wave thalweg over Central-Northern Europe between 16...18 April (Fig. 1, left). There was a cold air penetration in the lower troposphere towards the Genova Gulf region, where an underdeveloped low (D1) can be noticed at the time (Fig. 1, left – 16 April). The depression then moved towards the Black Sea basin, at the same time as the Azoric anticyclone ridge expanded (M1) and joined a cold, mobile anticyclone from the Greenland area (M2). Circulation intensified in the lower troposphere as a result of the rising pressure in the anticyclone centered in the UK region (M1 + M2), and a mass of arctic air reached the Mediterranean Sea basin, which generated the formation of a new low (D2) in the Genova Gulf. At the same time, the initial cyclone (D1) was northbound in the Black Sea basin (Fig. 1, right) and caused a cold air advection in the back of the cyclone after April 18th.

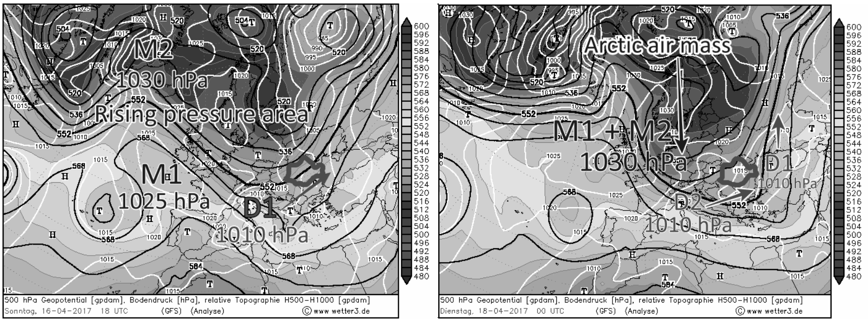

Fig. 1. ***Low sea-level pressure and 500 hPa geopotential (16 and 18 April 2017). Source: wetter3.de***

3.2. Event development (19 April 2017)

On April 19th, as a result of the depression's (D2) movement towards Romania, (fig. 2, left), precipitation occurred especially in south-western Romania (fig. 2, right).

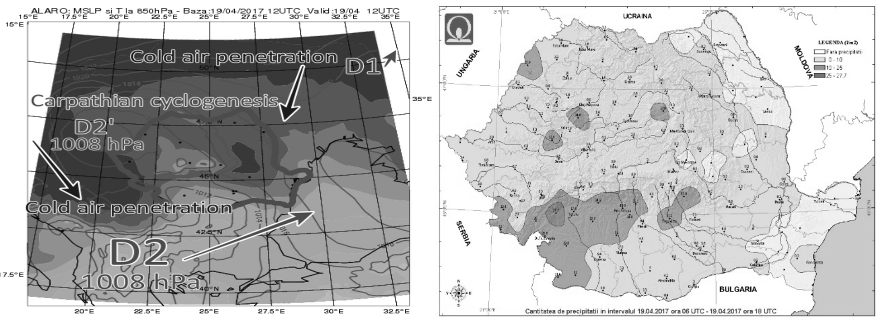

Fig. 2. ***Low sea-level pressure and temperature at 850 hPa (left) on April 19th, 12h00 UTC and precipitation accumulation over 12 hours until April 19th, 18h00 UTC. Source: A.N.M.***

Gradually, as the arctic air mass advanced from the west, snowfall was recorded in the morning on April 19th in mountainous regions, and during the day and in the evening in Transylvania, Maramureș, southern Banat and southern hilly areas. In the same time, the surrounding cold air blown upward the warm and humid air in Hungarian Plain, noticed by a rapid decrease of mean sea level pressure and a second cyclonic core over central Hungary (D2'). By 18h00 UTC, in low areas, snow layers of up to 7 cm had built up in Transylvania (Toplița), and of up to 2 cm in Maramureș (Ocna Șugatag), while in southern Banat only snow patches were reported (Oravița).

3.3. Event development (20-22 April 2017)

Consequently, starting with the morning of April 20th, as a result of the depression's movement over the Black Sea and the cold air advection from the north in eastern Romania, precipitation mainly fell in solid form throughout most of the country (Fig. 4, a). The presence of the -4 ˚C isotherm at 850 hPa and close-to-zero temperatures favored significant wet snow falls in Moldavia, up to 50…70 cm snow layer thickness in Bârlad plateau at the end of the event.

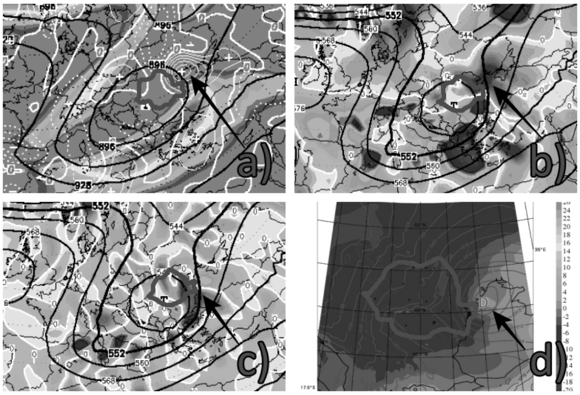

Fig. 3. April 20th, 12h00 UTC: ***Vorticity advection and geopotential at 500 hPa (c), thermal advection in the 1000-500 hPa layer and geopotential at 500 hPa (b), divergence in the upper troposphere and wind speed at 300 hPa (a), low sea-level pressure and temperature at 850 hPa (d). Source: wetter3.de (a, b, c), A.N.M. (d)***

Gradually, after noontime, the baric gradient quickly increased following the depression's deepening (D2) and the anticyclone ridge advancement (fig. 3, d), and winds started to intensify from the northern-north-western sector in most Moldavian regions with wind gusts of 55...75 km/h (fig. 4, b). Altitude conditions were favorable to the rapid decrease of the cyclone's pressure (fig. 3 – a, b, c). During the night between the 20th and the 21st of April it snowed abundantly (Fig. 4 - c) and, at certain stations, the newly-deposited snow layer exceeded the maximum recorded that winter. The temperature decrease slightly under 0˚C resulted in unstable powder snow deposits that enhanced the blizzard in the central part of the region. The cyclone also amply developed vertically, and the 500 hPa (Fig. 3, c) center shifted to the west with respect to the ground-level center (Fig. 3, d), which indicates this core was still highly active, considering the notable westward tilt of the vertical axis. On the morning of April 22nd, as a result of the sky clearing and the presence of the cold air mass, the minimum temperatures were negative throughout most of the country and reached -5 ˚C in Muntenia and -9 ˚C in eastern Transylvania, which was 10 ˚C colder than normal for this time of the year. All regions reported rime and scattered cases of ground-level freezing.

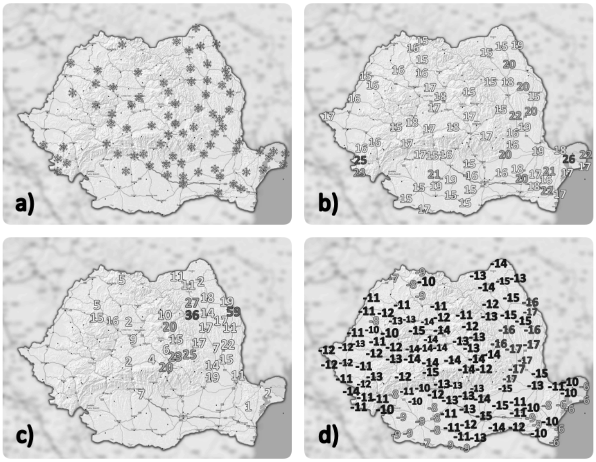

Fig. 4. ***Snow and sleet at stations located in hilly and plain regions between 18-21 April 2017 (a), peak wind gust speed at 10 m between 18-22 April 2017 (b), maximum snow layer thickness at meteorological stations (c), deviation of maximum air temperature from the mean multiannual (1981-2010) value on April 20th, 2017. Source: A.N.M.***

Fig. 5. ***Consequences of the winter event in Moldavia – 20…21 April - (Neamț and Galați counties). Source: http://www.facebook.com/SWRomania***

4. SEVERE APRIL COLD OUTBREAKS - A CLIMATOLOGICAL PERSPECTIVE

In order to identify the long-term occurrence frequency of severe cold air outbreaks in Romania, we used NOAA reanalysis maps for the period 1961-2015. All the days when the -5 ˚C isotherm at 850 hPa reached the Romanian territory were considered in the process. A total of 90 such severe cold days were identified in this period, i.e. an average of 1.7 days per year, which indicates that these instances do not occur every year in April. While the 5-year frequency (fig. 6) indicates no clear linear trend, until 1995 a quasi-oscillation with a minimum in 1971-1975 can be easily observed. After 1996, this oscillation is disturbed, with a total lack of such days between 2006-2010, but also with the highest number recorded between 2001 and 2005. A certain link between this chaotic behavior over the past 2 decades and recent climate change could be inferred.

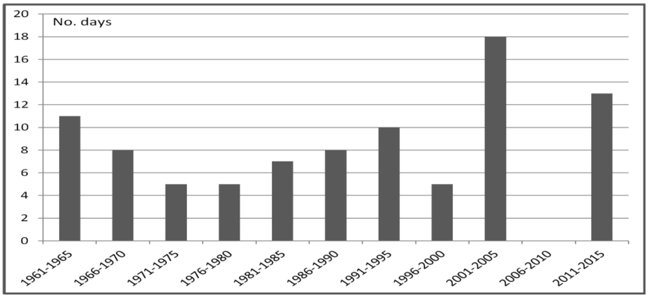

Fig. 6. ***The number of days per 5 year-periods with severe cold outbreaks in Romania in April (1961-2015)***

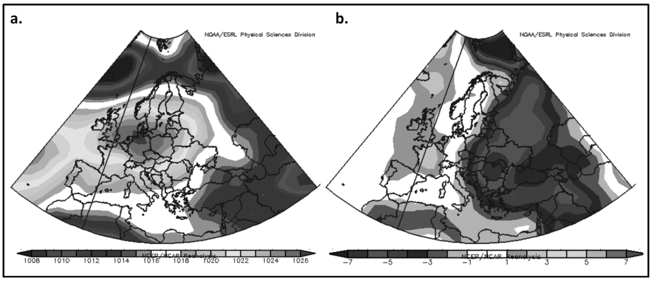

Fig. 7. ***Composite maps for mean sea level pressure (left) and air temperature anomalies for the most important cold outbreak events in April for 1961-2015 (right)***

Upon analysis of daily weather bulletin archives provided by the Romanian Meteorological Administration for the month of April for the same period (1961-2015), we identified 4 other events during which generalized snowfall and even blizzard conditions were reported in Moldavia: 8-10/1969, 16-18/1981, 14-16/1996, 8-10/1997. However, the 2017 events were the most severe and the latest for this month. Using the NCEP/NCAR database (Kalnay et al., 1996), we also explored the average synoptic weather conditions during which the events occurred (fig. 7 - left). Thus, based on the continental-scale composite maps of these events for sea-level pressure (fig. 7 - right), it can be noticed that the 2017 pattern is typical for this kind of atmospheric phenomena. The advancement towards Central Europe of a high-pressure core represents the key element for the development of such phenomena. This anticyclone usually develops in the ridge of Azores High, but its origins can rather be placed in Greenland or in North Atlantic regions, i.e. a cold-core anticyclone developed as a polar mobile anticyclone according to

Leroux's criteria (2000). This anticyclone generates intense cold advection in the front/eastern sides and determines severe cold outbreaks in Eastern Europe. As a result of this cold air advection, Romania is placed in a region that has the highest negative temperature anomaly (fig. 7 - right) on the continent. In fact, the Romanian climatological literature traditionally associated these conditions with the action of the Scandinavian anticyclone, a pressure center which causes the majority of severe cold outbreaks during autumn and spring in our region (Stăncescu, 1983). Nevertheless, even though the action of this anticyclonic center is associated more often with cold air outbreaks in Romania (fig. 6), snowfall and blizzard conditions, such as the ones recorded in 2017 and 4 other cases mentioned above, only occur when a cyclonic center develops in the Mediterranean region, following a trans-Balkan path. As a result of the fact that the region of Moldavia is the first Romanian region where these air masses are going into, the intensity of winter phenomena is higher.

5. CONCLUSIONS

The winter events reported between 19...22 April 2017 were extreme. Although the advancement of the arctic air mass and the cyclogenesis in Genova Gulf did not have any very unusual large-scale features, the negative effects were significant due to mesoscale conditions and the calendar date on which this late winter event occurred. Air temperature in the vicinity of the subjacent area around 0 ˚C led to notable wet snow deposits on April 20th. Subsequently, trees and electrical cables collapsed under the action of the wind and wet snow, which froze over during the night between the 20th and the 21st of April. Thus, heavy damage was reported at agricultural crops and orchards in several regions of the country due to the initial solid deposits, and afterwards, on April 22nd, in the morning, due to the low temperatures that favored hoarfrost formation and ground-level freezing. In the morning of April 21st, several national roads were closed because of the blizzard and massive snow deposits and drifts, and power outages and water supply, internet and communications interruptions were reported in several Moldavian counties. Climatologically, while the synoptic structure of 20-21 April played the largest role in the occurrence of the most powerful blizzards in Moldavia, it is also typical of late winter events. While four other snowfall and blizzard events were identified in the month of April in the 1961-2015 interval in Moldavia, the one studied in this paper is the latest and the most violent, which reaffirms the fact that, despite an increasingly warm climate, late winter events remain important risk phenomena in eastern Romania.

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