RADAR CLIMATOLOGY OF HAIL IN THE APUSENI MOUNTAINS

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ABSTRACT. - Radar Climatology of hail in the Apuseni Mountains A new method for the assessment of large areas with frequent occurrence of hail in a fine spatial resolution and its application for the Apuseni Mountains and their adjacent areas is presented. Due to the fine tempo-spatial resolution of the radar detection, the creation of radar climatology of the areas where the hail production conditions are determined is imposed. With the help of two Doppler radars at Oradea and Bobohalma, the area of interest is examined and spatial maps of the relative frequency of hail contained in the clouds are made. Composite maps are made (by superimposing the two Doppler radar images from Oradea and Bobohalma) of the areas in which clouds with hail of different sizes occur.

Keywords: hail, Doppler radar.

1. INTRODUCTION

The creating of radar climatology of the areas where the hail production conditions are detected is imposed due to the fine tempo-spatial resolution. Local influences on convective circulations are due to the topographical issues, the effects of the mountain-plain dynamics, the upwelling effects on the wind exposed slopes, the convergence areas on the sheltered side of the mountain and the sources of heat on sunny slopes. The analysis highlights the known outcome that the dynamic effects of the mountains have a significant impact on the local air flow, affecting the climate of the adjacent regions.

The diversity and complexity of the Apuseni Mountains is reflected in the great number of climate processes generated and influenced mainly by the relief, which determines the size of these changes, namely the orientation of the peaks towards the general circulation, the exposure of the slopes against the solar radiation (with the largest contrasts between the northern and southern respectively, with different shading and sunlight).

Kunz and Puskeiler (2010) a implements new method for the assessment of the hail hazard in high spatial resolution and its application for Southwest Germany are presented. Besides the detection of hailstorm tracks between 1997 and 2007, maximum reflectivity is projected on a 10 km × 10 km grid and analyzed by

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extreme value statistics. The results confirm a high spatial variability of both track density and hail hazard. Severe hailstorms occur most frequently, and consequently also with highest intensities, in the region south of Stuttgart, whereas hail activity is lowest over the Rhine valley and the low mountain ranges of the Black Forest and Swabian Jura.

The relief also acts through altitude and configuration - convex shapes are continuously exposed to movement, and the concave one by the frequent presence of calm and thermal contrasts between day and night, winter and summer - thermal inversions and valley corridors or the depressions are characterized by turbulent ventilation and increased turbulent mix.

Hail is one of dangerous weather phenomenon that is difficult to predict in time and space. This study complements the climate data.

2. ANALYZED DATA

Maps of relative frequency with distribution of hail in the area of the Apuseni Mountains, with grid up to 5 km were made. Thus a network of 190 x 125 km^2 = 23,750 km^2, consisting of 950 pixels, each of 25 km^2 covering the whole area of the Apuseni Mountains and the adjacent areas is obtained. The data based that was analyzed includes the summer months (June, July and August) between the years 2004 and 2009, data supplied by the WSR-98D Doppler radars at Oradea and Bobohalma. The analysis is similar to the obtained by Maier (2009), for which the grid step was of 25 km.

Images with the relative frequency of the areas where storm cores are detected by both radars are made. At the next step, a filtering of the nuclei according to the degree of severity is done, choosing as a threshold value of separation of 70% for both severe hail as well as normal.

The study focused mainly on a comparison analysis between areas with relative high frequency of occurrence of hail, determined by the composite reflectivity data (Figure 1a and b) supplied by the two radars and the territorial distribution of the hail image extracted from the Climate of Romania (2008) Figure 3. Thus, common areas where the relative frequencies of the occurrence of storm cores, which are close as values to the areas with major differences in the distribution of nuclei, are identified.

Taking into account the place that the Apuseni Mountains occupy, an "orographic barrier” in the way of dominant atmospheric circulation and positioning of the two Doppler radars at Oradea and Bobohalma (occultation - resolution drop behind the mountain massifs), the analysis finally led to the realization of composite maps. Thus, two composite maps of relative frequency formed by the maximum values of common pixels are made. A map showing the general distribution of the hail, the other one showing the distribution of large hail (> 1.9 cm).

3. SPATIAL ANALYSIS OF HAIL

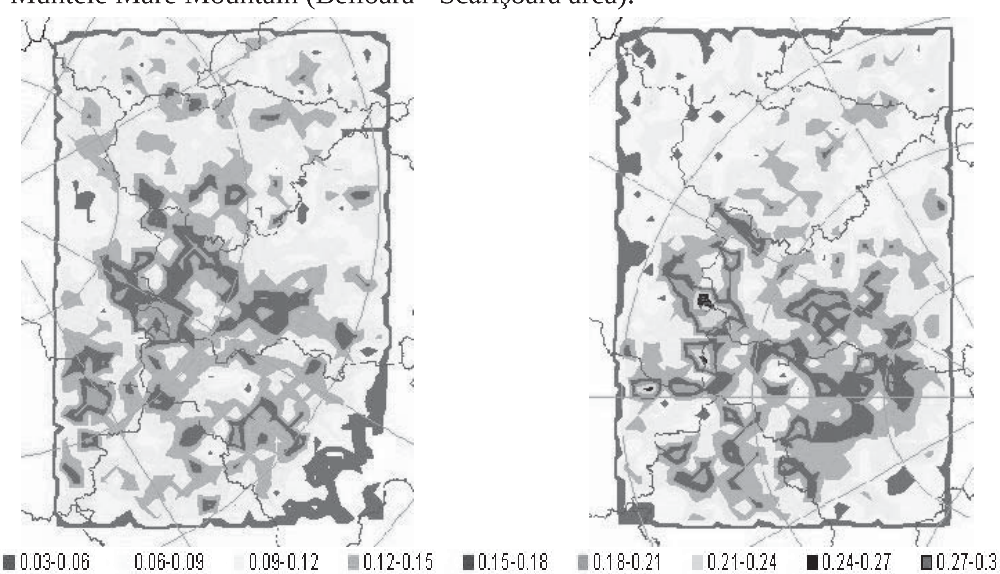
The analysis of cloud formations containing hail, detected by radar echoes highlights within the Apuseni Mountains area, various zones of expansion in the number of cases according to a number of factors such as distance from the radar location, the altitude of mountain units and the altitude of various cloud formations as well as their thickness.

Classification was realized on three classes of values: low values (0.03 to 0.09%), average values (0.09 to 0.21%) and high values (above 0.21%). Figure 1 a) and b)

Low values have the largest expansion in the eastern region of the Apuseni Mountains and the western hills. The same values describe two other areas with extensions in the Almaş-Agrij-Someşean Plateau to penetrating the Basin of the Crişul Repede river (eastern side of Vlădeasa peak) and south-eastern part of the Apuseni mountains and Mureş Valey and the Vinţului Mountains. Low values outline areas that overlap some depression areas or depression basins such as Câmpeni-Abrud, Moneasa, Răchiţele, Ciucea, Vârfurile.

The average values were grouped two subclasses: between 0.09% and between 0.15% and 0.15% and 0.21%. These classes of values are representative as extension for the whole of the mountains. The first class (0.09 to 0.15%) dominates in Zărand, Codru Moma, Pădurea Craiului and Plopiş Mountains and the second subclass (0.15 to 0.21%) has highest extension in the Metaliferi, Trascău, Gilău-Mare Mountains.

High values (0.21-0,24%) and very high values (above 0.24%) outlines several small zones in the Codru Moma Mountains (in the Pleşu-Izoiu area), Bihor-Vlădeasa (Magura Vânăta-Cârligaţi area and the Beiuşele-Poieni peak) and Muntele Mare Mountain (Belioara - Scărişoara area).



a) WSR-98D Oradea ***b) WSR-98D Bobohalma***

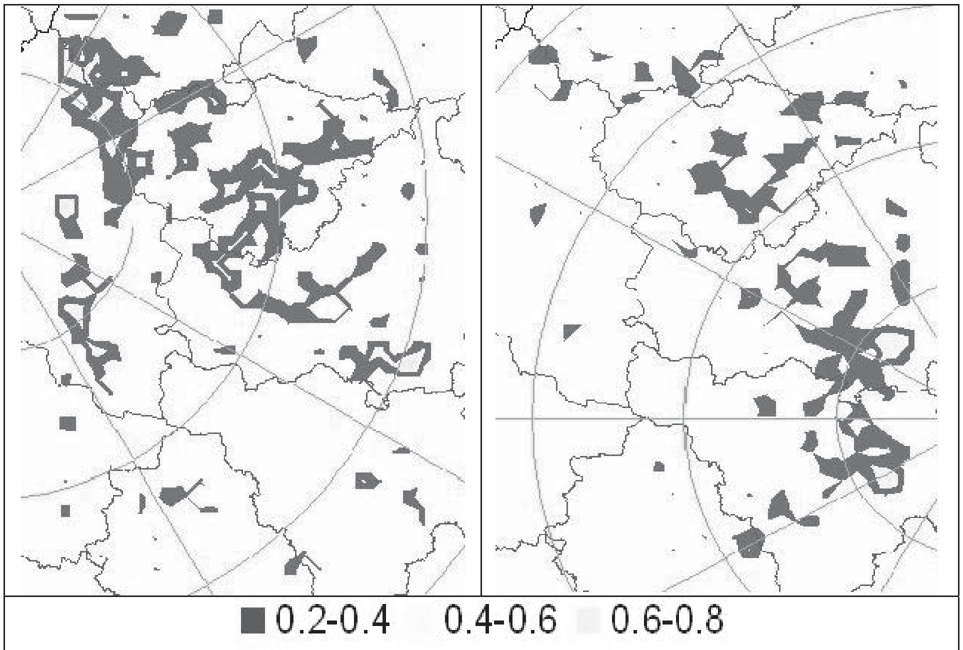
Figure 1. ***Apuseni Mountains area - map of relative frequency with the genera distribution of hail using the WSR-98D radar***

Figure 2. ***Apuseni Mountain Area* – *composite map of relative frequency with general repartition of hail***

Figure 3. ***Territorial distribution of the average annual number of days with hail (1961-2000) (Romania's Climate 2008)***

4. SPATIAL ANALYSIS OF LARGE HAIL

A separate analysis for the areas with large hail is realized. Figure 4 a) and b). Cloud formations develope in high mountain areas and a trend towards the depression, both intra-mountains and adjacent to the Western Mountain.



a) WSR-98D Oradea	*b) WSR-98D Bobohalma*

Figure 4. *Apuseni Mountains area - map of relative frequency the distribution of large hail (> 1.9 cm) using the WSR-98D radar*

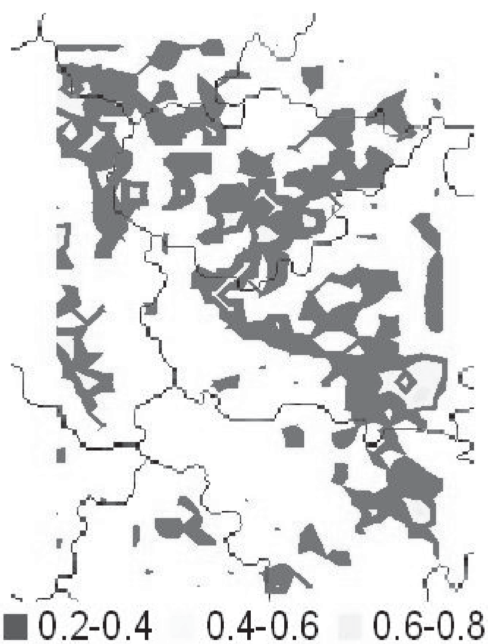


Figura 5. *Apuseni Mountains area – composite map of the relative frequency of the distribution of large hail (> 1.9 cm)*

Making composite map obtain figure 5. The Meseş is distinguish in this map and the Almaş-Agrij depression, the eastern sector of the Gilău - Muntele Mare Mountains and depression space Iara-Hăjdate-Săvădisla-Feleac Massif, the Trascău Mountain and the central-northern sector of the Alba Iulia-Turda depression corridor; the Vinţului Mountains - the Geoagiu area. Compact areas were detected in the Ciucea-Troops, Codru Moma - Beiuş Depression zone, areas in the Metaliferi Mountains such as Strâmbu-Pluton and Detunata-Geamăna.

5. CONCLUSIONS

The results confirm a large spatial variability of both density and frequency of hail. Consequently, severe hail occurs most frequently in depression regions and at the contact of the Apuseni Mountains at the west with the Plain of Crişana and at the east with the Transylvanian Depression, while cloud formations containing hail, generally of small dimension, are more common in the mountain area on the western slopes of the mountains, namely the Bihor, Vlădeasa and Zarand Mountains.

The estimation of hail occurrence is an innovative new task and the obtained data can be used for many purposes. The information could be used to identify regions with high frequencies of producing hail, and in these cases the most effective measures to prevent and diminish can be taken, given the increased damage created by hail on a large number of buildings, cars or agricultural areas. In terms of weather forecasts, warnings can be adapted to present the danger of hail and the regions can be easily identified.

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