THE ANALYSIS OF THE FREQUENCY AND THE TREND OF THE SQUALL PHENOMENON IN THE WESTERN ROMANIAN PLAIN, NORTH OF MUREŞ RIVER

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Abstract

In this paper, we used the meteorological data concerning the annual number of days with squall in the period 1961-2002, from 10 weather stations. The study was based on the analysis of the frequency and the trend of the phenomenon. We delimited the areas with the highest frequency of occurrence of the squall and established the causes of this frequency. It results that on the analysed territory, the most frequent cases of squalls are located in the low Someş Plain, at the eastern limit of Crişuri and Arad Plains, at their contact with Crişana Hills and Zarand Mountains, as well as to the South of Mureş River, in Aranca Plain. The phenomenon recorded an increasing trend only in the southern part of the territory, due to the increase of air temperature during the last decade, which affected more this area.

Key words: number of days with squall, frequency, tendency, climatic hazard.

INTRODUCTION

The squall-line is a complex meteorological phenomenon, characterized by a strong and sudden variation of the wind direction and speed, a sudden increase of air pressure (by 2-5 hPa) and relative air humidity and a sudden decrease of air temperature (by 10-15°C). The squall precedes or accompanies the stormy clouds (Cumulonimbus), therefore it is frequently accompanied by precipitation such as heavy rain, lightning and thunder, or even hail (according to „Directions for Weather Stations/ Instrucţiuni pentru staţiile meteorologice", I.N.M.H., 1995; Moldovan, 2003; Ţuţuriga, 1987).

The squall-lines usually precede the cold fronts by 30-60 km (prefrontal squall-lines) or may occur within the same air mass, below the very high Cb clouds (intramass squall-lines) (Ţuţuriga, 1987; Moldovan, 2003; Cristea, 2004).

The squall is a climatic hazard specific for the warm semester of the year, but it may also occur in the cold semester in special synoptic conditions. Because of its violence, it may inflict large material damages and indirectly even human casualties. Therefore, the knowledge of the areas where squalls occur frequently and the moment of the year favourable for their emergence is an important factor, which should be taken into account in the calculations regarding the design of constructions, transport lines, power and communication networks etc.

MATERIAL AND METHODS

In this paper, we used the meteorological data concerning the annual number of days with squall in the period 1961-2002 (42 years), from 10 weather stations located in the Western Romanian Plain, North of Mureş River. Some stations do not have the entire set of

data; as a consequence, the period of study in their case limited to 1970-2002. At three stations, the period of observation was even shorter, the same as their period of existence: Şiria (1984-2002), Ineu (1979-1997) and Salonta (1983-1998). All the meteorological data used in the paper were taken from the archives of the National Meteorological Administration (N.M.A.).

The study was based on the analysis of the frequency and the trend of the phenomenon. Thus, we delimited the areas with the highest frequency of occurrence of the squall – and therefore most frequently exposed to this climatic hazard – and established the causes of this frequency. We determined the distribution by decades and the linear tendency of the phenomenon during the analysed period.

RESULTS AND DISCUSSIONS

The average annual number of days with squall

In the Western Romanian Plain, North of Mureş River there is an annual average of *0.2-4.1 days with squall* (table 1 and fig. 1). The highest number is recorded at the northern station of Satu Mare (4 days annually), due to the fact that the north-western part of Romania is most affected by the advections of oceanic air masses, consequently it is most often crossed by the fronts of the Icelandic Cyclones.

Table 1

The average annual number of days with squall in the Western Romanian Plain, North of Mureş River.

Station/Period	Satu M.	Săcueni	Oradea	Salonta	Holod
1961-2002	3,6	-	1,4	-	-
1970-2002	4,1	0,5	1,7	0,5	2,6
Station/Period	**Chiş.Criş**	**Ineu**	**Şiria**	**Arad**	**Sânnic.M.**
1961-2002	-	-	-	0,2	0,9
1970-2002	0,5	0,3	1,1	0,2	1,1

A high number of days with squall is registered at the stations located at the contact between the plain and the Western Hills – Holod, Oradea and Şiria – because the squall becomes more intense at the feet of the slopes situated at right angle on the direction of the squall-line, which is usually formed above the eastern part of the Pannonian Plain. Here, the air masses enter a forced ascending movement, which coincides either with the dynamic convection movement of the warm air, generated by the cold front which suddenly raises the warm air to high altitude, or with the thermal convection generated by the powerful insolation of the day. This sudden rising movement of the warm air takes the shape of a whirlwind. Upper on the slopes, the upward movement makes the wind to reduce its speed, so the squalls disappear rather quickly in the hills and mountains (Drăghici, 1988, quoted by Moldovan, 2003).

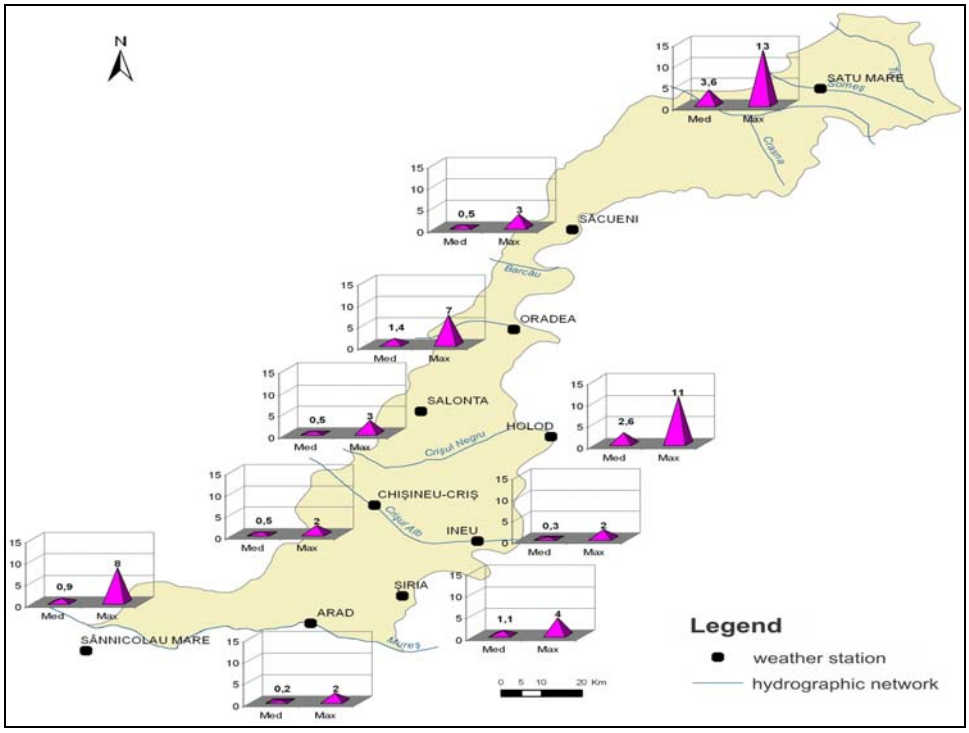

Fig. 1. The average and maximum annual number of days with squall, in the Western Romanian Plain, North of Mureş River (1961-2002).

A high number of days with squall is also registered at the southernmost station, Sânnicolau Mare (one day annually), because the temperatures are the highest here, generating intense convective air movements during the hot summer afternoons.

The lowest number of days with squall is registered at Arad and Ineu stations. The low number at Arad is due to the channelling of the air masses along the large valley of Mureş. When the wind intensifies, it keeps its direction; consequently, strong wind phenomena are recorded at the weather station instead of squall phenomena. In fact, the low number of days with squall at this station is due to the local morphological conditions. The low number of days with squall at Ineu is due to the small number of years of observation, but also to the shelter provided to this station by Zarand Mountains, against the southern and south-western winds. Săcueni station registers a relatively low number of days with squall, because of its sheltered position in the low, narrow and unventilated space of Ier Plain.

In conclusion, one can state that within the analysed territory, *the most frequent cases of squalls* are located in the *low Someş Plain, at the eastern limit of Crişuri and Arad Plains, at their contact with Crişana Hills and Zarand Mountains*, as well as to the South of Mureş River, *in Aranca Plain*.

The maximum annual number of days with squall

Compared to the average annual number of 0.2-4.1 days with squall, the maximum annual number raised to *2-13 days* during the 1961-2002 period (table 2 and fig. 1). The value was higher at the same stations where the highest average annual number was also recorded.

Table 2

The maximum annual number of days with squall, in the Western Romanian Plain, North of Mureş River (1961-2002).

Station	**Satu M.**	**Săcueni**	**Oradea**	**Salonta**	**Holod**
Value	13	3	7	3	11
Year of occurrence	1984	1985	1974	1985	1979
Station	**Chiş.Criş.**	**Ineu**	**Şiria**	**Arad**	**Sânnic.M.**
Value	2	2	4	2	8
Year of occurrence	1971,1977 1982,1989	1995	1992 1998	1996	1999

Table 2 indicates that the *maximum annual number of days with squall was registered during the second and third decade at the stations of Someş Plain and most of Crişuri Plain*, and *during the last decade in south-eastern Crişuri Plain, in Arad and Aranca Plains*. The recording of the highest number of days with squall during the last decade, in the southern part of the analysed territory, is due to the increase of the air temperature during the recent years, affecting mostly, because of its effects, the southern and south-western Romania. The increase of the air temperature and consequently of the soil led to intensification of thermal convection during the hot summer months, which contributed to the amplification of phenomena that generate squalls.

Generally, the years with highest values (fig. 2-4) are concentrated in the period *1974-1987*, but also *1997-2001*. However, there are much lower values during the latter period than the first one. So, the *maximum values occurred mainly during the second and third decades*, the same as in the case of the number of days with lightning and thunder and those with hail (Şerban, 2008). This fact also leads to the conclusion that the squall is strictly connected with atmospheric instability, with the formation of convective clouds having a large vertical development, which generate heavy rain, lightning and thunder, hail, but also frequent squall phenomena. The period 1974-1987 coincides with the one with highest values of air humidity, 1975-1989, but also with the one with high amounts of precipitation, 1974-1981. The period 1997-2001 is also one with large amounts of precipitation.

Between 1961 and 2002, the stations that registered years with a number ≥ 5 days with squall were: Satu Mare (11 years), Holod (8 years), Oradea (3 years) and Sânnicolau Mare (2 years). All the other stations recorded only years with less than 5 days with squall. These are the locations which present the highest risk for this meteorological phenomenon. The same as in the previous cases, one may remark the highest frequency of the squall at Satu Mare and Holod stations.

The very low number of days with squall during the first decade is due to the drought, which occurred mainly during the first part of the decade. However, it may also be caused by the weather stations operators' capacity to recognize the phenomenon, which resulted in its absence from the registers of observations at the stations.

The minimum annual number of days with squall

The minimum annual number of days with squall was *0 days* at all the stations in the plain. Between 1961 and 2002, the squall was not occurred in about 18-36 years at the weather stations with the entire set of observations (only in 6 years at Satu Mare, where the phenomenon had a high frequency) and in about 9-15 years at the stations with a shorter period of existence. The squall was less occurred at Arad station (36 years of the total of 42 analysed years), where it had the lowest annual frequency.

Figures 2-4 present the *linear tendency* of the annual number of days with squall. One may notice that the tendency is *constant* between 1961 and 2002 in the low Someş

Plain and in the northern Crişuri Plain. However, at Săcueni, Holod and Chişineu-Criş stations, the tendency is *decreasing*, but the rate of decrease is insignificant. The decrease is due to the lack of observation data during the decade 1961-1970, with a poor frequency of the phenomenon, and to the very low values of squall frequency recorded during the last decade, 1991-2002. For instance, at Săcueni, there was no squall between 1986 and 2002, reason for this station to register the highest decrease.

At the southern limit of the analysed territory, at Arad and Sânnicolau Mare, the tendency is of *increase*, with the highest coefficient at Sânnicolau Mare. The increase in the number of cases of squalls in Aranca and Arad Plains is due – as mentioned before – to the increase of air temperature during the recent years, which amplified a lot the thermal convection in this area during the months of the warm semester. In its turn, the convection intensified the atmospheric fronts crossing the area, therefore generating dangerous meteorological phenomena.

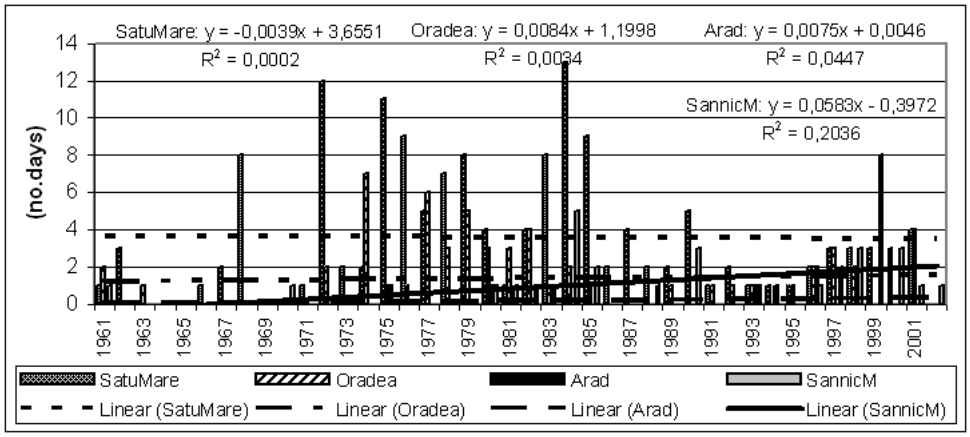

Fig. 2. The annual number of days with squall and its linear tendency, in the Western Romanian Plain, North of Mureş River (1961-2002).

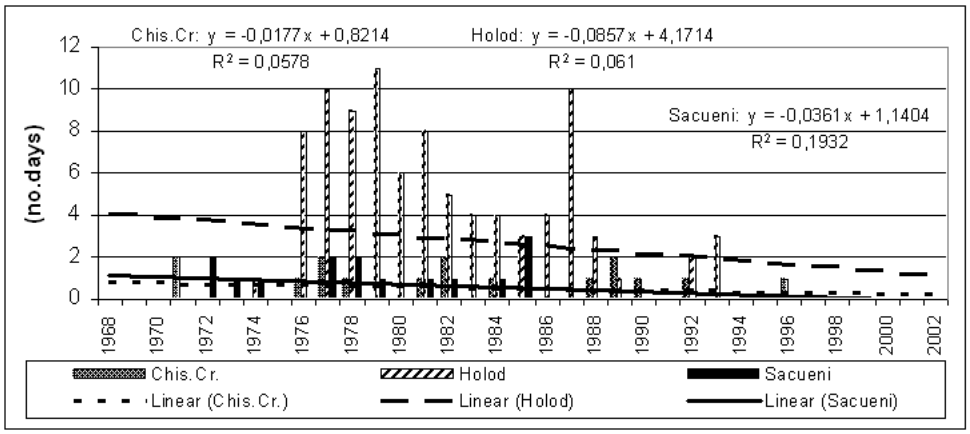

Fig. 3. The annual number of days with squall and its linear tendency, in the Western Romanian Plain, North of Mureş River (1968-2002).

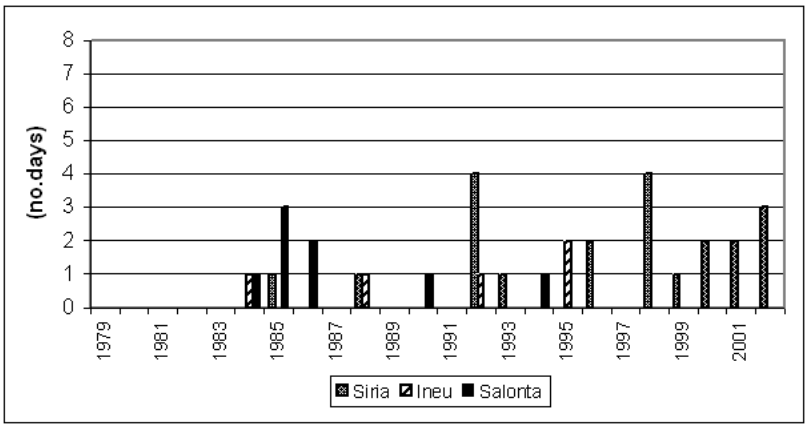

Fig. 4. The annual number of days with squall at the stations Şiria (1984-2002), Ineu (1979-1997) and Salonta (1983-1998).

The tendency chart was not made for Şiria, Ineu and Salonta stations, because their period of observation is too short, and the resulted tendency would not be relevant and comparable to the other stations.

CONCLUSIONS

On the territory of the Western Romanian Plain, North of Mureş River, the hazards caused by the presence of squalls maintained a constant level in the period 1961-2002. In the lower, sheltered parts of the alluvial plains, as well as in the proximity of the gulf-basins, they decreased in the recent years. In the southern part of the analysed area, in Aranca and Arad Plains, they increased recently, because of the increase of the air temperature during the last decade.

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