

CLIMATIC RISK PHENOMENA IN THE WARM PERIOD OF THE YEAR, IN THE CRISURILOR PLAIN

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Résumé: *Phénomènes climatiques de risques de la période chaude de l'année produites dans la Plaine de Crișuri.* Dans cette ouvrage, nous avons analyse les risques climatiques qui se produisent dans la période chaude de l'année, c'est-à-dire: les températures extrêmes, les sécheresse, les quantités exceptionnelle des précipitations, la grêle, le vent fort et le tempête. L'analyse des sécheresses est réalise sur la base de la durée, on utilisant la définition de la période de sécheresse de Hellman. Autrement, nous avons calcule la fréquence et le degré d'assurance des quantités annuelles des précipitations maximales en 24 heures, que le nombre de jours de la grêle, vent fort et le tempête par l'analyse de leur fréquence. En plus, nous avons suivi leurs évolutions en temps.

Mots-clés: température maximale absolue, sécheresse, quantités maximales des précipitations journalières, grêle, vent fort, tempête.

Introduction

Plains, the most important agricultural domains, assess the necessity of knowing the extreme meteorological phenomena, which have a major impact upon the environment and especially upon the crops. This idea drove us to analyze the climatic risk phenomena in the warm period of the year in the Crisurilor Plain (extreme temperatures, droughts, maximum precipitation amounts within 24 hours, hail, strong wind and squall), their evolution in space and time and their assurance degree.

Data and Methods

In the present work, the study of the drought phenomenon has been made based on the drought spells analysis. Hellman, the Director of the Prussian Meteorological Institute, first introduced the terms "*drought spell*" and "*dry spell*" at the end of the 19th century (O.Bogdan, 1978). By *drought spell* he understood *the period of at least 14 consecutive days within the interval October-March and at least 10 consecutive days in the interval April-September, intervals in which no precipitation fall or, the precipitation does not tote up more than 0.1 mm* (N.Topor, 1964, quoted by O.Bogdan, 1978).

As to correctly place – within one month or another – a drought spell spread over two consecutive months, the definition given by Dauphiné (1975) has been used: *the drought intervals are counted for the month that contains the longest sequence of days without precipitation* (Anagnostopoulou et al., 2003).

As to determine the annual maximum precipitation amounts in 24 hours correspondent to some characteristic assurances (1, 2, 5, 10, 20, 25, 50, 80 and 100%), the assurance has been calculated with the formula:

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$$p = \frac{m - 0,3}{n + 0,4} * 100(\%)$$

where m marks the order number of the data sequence, ordered decreasingly and n the number of observation years (I. Marin, 1986).

The summer season climatic risks have been analyzed for a number of 8 weather stations, located within the Crisurilor Plain or at its boundaries. As to emphasize certain meteorological phenomena, data have been taken from only a few weather stations, respectively the ones that had a common observation period. Thus, the results were easier to compare and synthesize. The chosen analysis period was 1961-2000, respectively for some phenomena, 1970-2002. Siria Station has been operational only since 1984 and the Stations Ineu and Salonta are closed. They functioned between 1979-1998 (Ineu), respectively 1983-1999 (Salonta).

Results and Discussions

1. Absolute Maximum Temperature

Absolute maximum temperatures were recorded, at all the stations, in **August** (fig.1) and oscillated between 38.7°C at Ineu and 40.4°C at Arad. As it was expected, these values decrease from south to north, as latitude increases but also from the west to the east as the altitude increases. They occurred in August due to the anticyclonic baric situations that prevail in this time when the air masses, persistent over the land, get warmer and warmer and expand.

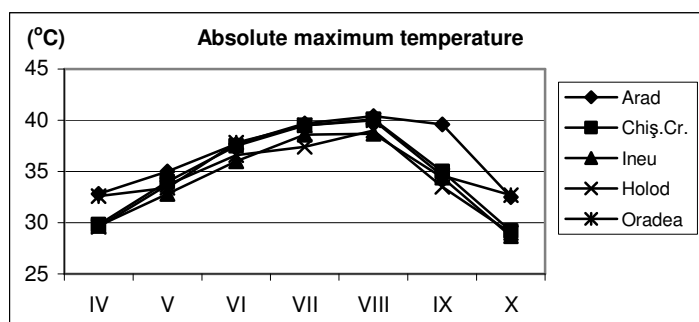


Fig.1 The path of the absolute maximum air temperature in the Crisurilor Plain.

At the south of the Crișurilor Plain, the absolute maximum temperatures occurred in the consecutive days of August 15th 1952 (40.1°C at Chisineu-Cris) and August 16th 1952 (40.4°C at Arad), respectively towards the eastern boundary of the plain, at its contact with the Western Hills on August 21st 2000 (40.0°C at Oradea and 39.0°C at Holod). That is they occur in one of the hottest and driest years. At the Ineu Station, the absolute maximum temperature was reported in 1992, on August 28th and it was 38.7°C.

Along the warm period of the year, the lowest values of the absolute maximum temperatures occurred in *October* that is at the end of the period.

2. Drought phenomenon

2.1 Drought spells

Within a year, over the Crisurilor Plain territory may occur, on the average, 4 drought spells with an average duration of 16 days (at the stations Arad and Oradea) and 15 days in the north (Sacueni Station). Consequently, using the analysis method offered by Hellman, we can say that on the Crisurilor Plain territory may occur, on the average, 2 months of drought a year. That is 2 months a year without any precipitation at all.

The duration of the drought spells varies between 10-44 days. The longest spells are recorded for the stations Oradea – 44 days, respectively 42 days – and Arad – 40 days,

respectively 39 days (table 1). The highest number of the drought spells – spread over more than 30 days – are recorded at the southern station of Arad (6 spells), followed by Oradea (5 spells) and Sacueni (4 spells). Consequently, on the analyzed territory, *the number of the longest drought spells decreases as the latitude increases.*

The longest drought spells (duration > 30 days) in the Crisurilor Plain (1961-2000).

Table 1

STATION	DROUGHT SPELL	DURATION (no. days)
Arad	25 Nov.1972 – 3 Jan.1973	40
	24 Aug. – 1 Oct.1961	39
	25 Sept. – 26 Oct.2000	32
	30 Sept. – 30 Oct.1995	31
	9 April – 9 May 2000	31
	28 Oct. – 26 Nov.1978	30
Oradea	25 Nov.1972 – 7 Jan.1973	44
	9 Sept. – 20 Oct.1961	42
	31 Aug. – 7 Oct.1986	38
	2 Oct. – 1 Nov.1995	31
	25 Sept. – 24 Oct.2000	30
Sacueni	8 Sept. – 14 Oct.1961	37
	25 Sept. – 26 Oct.2000	32
	8 Dec.1972 – 7 Jan.1973	31
	1 – 31 Dec.1973	31

Among the longest drought spells which occur during the warm season, the most important are the intervals Sept.-Oct.1961, Sept.-Oct.2000 and Oct.1995, in which autumn drought was long and manifested over the entire surface of the plain.

Over the entire studied period (1961-2000), most of the drought spells occurred at Sacueni Station (157 spells), located on the low, alluvial plain, then Arad Station, the most southern one, followed by Oradea Station at the contact with the Western Hills, area with richer precipitation (table 2).

Table no. 2 shows that the most frequent drought spells are those that last between 10-20 days, and those between 41-50 days are missing at most of the stations (except Oradea). The higher the frequency of the drought spells, the smaller their duration.

The absolute frequency (number of cases) of drought periods on spells categories in the Crisurilor Plain (1961-2000).

Table 2

Frequency/spells categories (no.of days)	Drought spells		
	Arad	Oradea	Sacueni
10-20	134	130	133
21-30	17	16	20
31-40	5	2	4
41-50	-	2	-
Total	156	150	157

The **monthly** analysis of the drought spells emphasized the fact that they may occur in any month of the year. However, most of the spells occur during the interval **July-October** with a maximum in **September**, over the entire territory of the plain, when situations of anticyclonic weather prevail. There is another secondary maximum during the year, recorded in **April** at all the stations. So, we can observe *the presence of an autumn drought, more intense, and a spring, weaker drought*, over the territory of the Crisurilor Plain, droughts occurring at the beginning and at the end of the vegetation period of the plants. During the warm period of the year, **June** has the fewest drought spells, as it is the month of the pluviometric maximum.

As most of the drought spells occur during the intervals July-October and April, the warm period of the year, exactly the period with maximum need of water for the crops, the simultaneous occurrence of the hydric and thermic stress, may drive to the substantial drop of the crops.

2.2 Number of drought days

Because of the various durations of the drought spells, the number of the drought days has been studied, as this method offers a better analysis of the phenomenon (O.Bogdan, 1980). So, in the Crisurilor Plain occur, on the average, between **60-61 drought days per year**. *That means there is no rainfall for about 2 months a year*. The number of these days diminishes from the south (61 days at Arad Station) to the north (60 days at Oradea and Sacueni), as latitude increases.

The highest annual number of drought days exceeds 100 days at all the stations (fig.2). The diagram emphasizes the 1961 drought (105-125 days) and the 2000 drought (127 days at Arad Station), more intense in the south of the plain, on the background of the reduced air humidity and higher temperatures. Over the entire plain the annual number of drought days show increasing and decreasing periods. So, the increasing periods are: 1961-1962, 1967-1978, 1982-1997 and the intense 2000 drought. Between them, there are short rainy periods.

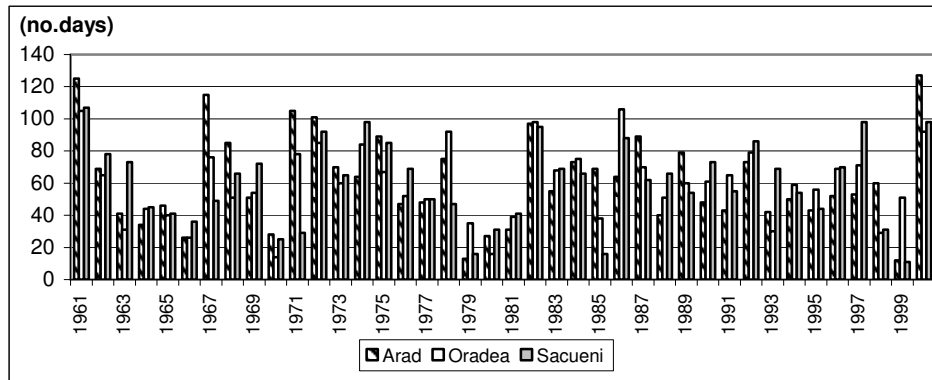


Fig.2 Distribution of annual number of drought days in the Crisurilor Plain (1961-2000).

The **monthly** analysis of the number of drought days (fig.3) shows again that most of the drought days produce in the interval **July-October**, with 5-12 drought days per month. These are the driest months of the year. The maximum of the drought days is recorded in **September** or **October** (10-12 days). Thus, the September maximum occurs at the northern stations Oradea and Sacueni (10 days) and the October maximum at the southern station Arad (with an average of 12 drought days). These months` drought is due to the prevalence of the anticyclonic regime. August has on the average, about 8 drought days and July about 5-7. In this case also a secondary maximum of the drought days occurs in April. *An autumn and a spring drought* are emphasized again, *the autumn one being more intense*. The spring drought may affect the course of the plants vegetation period because of the low soil moisture.

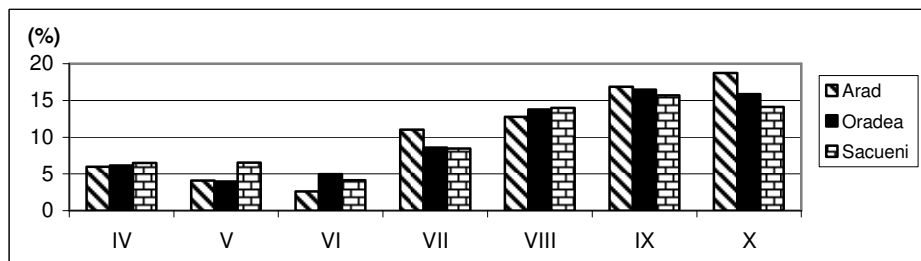


Fig.3 Monthly frequency of drought days in the Crisurilor Plain (1961-2000).

In conclusion we can say that in the Crisurilor Plain the drought phenomenon may produce *in any month of the year, with the highest intensity in the interval July-October.*

3. Maximum precipitation amounts within 24 hours

In the Crisurilor Plain *the annual average amounts* of the precipitation maximums fallen within 24 hours are between 37.2-43.3 mm. They increase from west to east, towards the Western Hills, where the higher relief causes the growth of the precipitation generating processes on the exposed slopes. So, the highest annual average amounts are recorded for the stations Holod (43.3 mm) and Oradea (40.8 mm), both located at the contact of the plain with the hills.

The highest maximum diurnal precipitation values recorded for the period 1961-2000 in the Crisurilor Plain are between **62.4-98.3 mm** (table 3). They didn't exceed 100 mm – as it happens in the south and south-east of the country – thus emphasizing the moderate characteristic of the western part of the country climate, with oceanic influences. The highest values are recorded for the station Chisineu-Cris where the summer thermic convection is more intense due to differences in albedo of the two main soil types (light colored halomorph soils and dark chernozems) (M.Cristea, P.Cristea, 1989). Holod Station also has high values.

The annual maximum diurnal amounts between **30.1-40.0 mm** (between 8-17 cases) have the highest frequency, followed by those between 40.1-50.0 mm and 20.1-30.0 mm (table 4). For Holod only, amounts between 40.1-50 mm have the highest frequency as this station recorded the richest precipitation amounts over the analyzed territory. As annual maximum diurnal values increase, their frequency decreases. Also low frequencies have annual amounts fewer than 20 mm.

The highest maximum diurnal precipitation amounts recorded in the Crisurilor Plain (1961-2000).

Table 3

STATION	Arad	Chişineu-Criş	Holod	Oradea	Sacueni
Amount (mm)	71,0	98,3	83,7	62,4	76,6
Day	28.07.1998	30.06.1974	7.06.1981	30.06.1986	2.09.1976

Absolute frequency (number of cases) of the annual maximum precipitation amounts within 24 hours in the Crisurilor Plain (1961-2000).

Table 4

STATION	10,1-20	20,1-30	30,1-40	40,1-50	50,1-60	60,1-70	70,1-80	80,1-90	90,1-100
Arad	1	8	17	7	5	1	1	-	-
Chis.-Cr.	1	11	15	8	-	1	1	-	1
Holod	-	6	8	12	3	2	-	2	-
Oradea	2	5	16	8	5	4	-	-	-
Sacueni	-	11	13	7	7	1	1	-	-

The annual maximum precipitation values within 24 hours occurred mostly in the interval *April-October* for all the stations, that is in the warm period of the year. Most of the annual values occur though during the summer months *June-August*, due to the frontal activity and also to the emphatic thermic convection typical for these months, and which induces clouds and precipitation development. During the intervals April-May and September-October, annual maximum diurnal values have a lower frequency (about 1-5 years out of 40 analyzed) because of the air temperature drop.

The assurance degree of the annual maximum precipitation amounts within 24 hours is of great interest because of the risks these amounts produce. Calculations show that the highest assurance degree, 100%, have the lowest precipitation values for every station, between 19.4 mm for Chisineu-Cris and 22.6 mm for Sacueni (table 5). These amounts may occur every year. Every 2 years (50% assurance) values between 34.8-41.0 mm occur. As the assurance degree drops, precipitation values rise and became scarcer. Thus, once in 20 years (5%

assurance) amounts between 61.7-80.1 mm produce, and once in 100 years (1% assurance) the highest amounts fall: between 62.7 mm in Oradea and 105.1 mm in Chisineu-Cris.

It can be noticed that values corresponding to characteristic assurances are most of the time higher in Holod – where the richest precipitation fall – and Chisineu-Cris for 1% and 2% assurances, on the background of thermic contrasts, as an effect of the unequal terrestrial warming.

Monthly maximum precipitation amounts within 24 hours vary a lot from a month to the other, according to the generating factors. The highest values produce during the warm period of the year, especially in the interval *May-October* (40-98 mm). The maximum is recorded in **June** (60-98 mm), the month of the pluviometric maximum (fig.4). It follows *July* (50-80 mm) and then *August* (40-57 mm). These are the warmest months of the year, when thermic convection drives to the intensified precipitation. Only at the southern and northern boundaries of the plain the highest values produced in July (Arad: 71.0 mm) respectively September (Sacueni: 76.6 mm) instead of June.

The maximum annual precipitation amounts within 24 hours with various assurances (1961-2000).

Table 5

STATION	ASSURANCE (%)								
	100%	80%	50%	25%	20%	10%	5%	2%	1%
Arad	19,7	29,3	35,9	44,7	49,9	55,1	62,5	70,2	73,2
Chis.-Cr.	19,4	25,8	34,8	40,4	42,5	48,5	75,0	96,8	105,1
Holod	20,9	30,7	41,0	47,9	51,8	67,4	80,1	83,6	84,8
Oradea	19,7	31,5	38,0	49,3	51,5	60,4	61,7	62,3	62,7
Sacueni	22,6	27,4	35,8	46,4	50,9	53,4	63,3	75,5	79,6

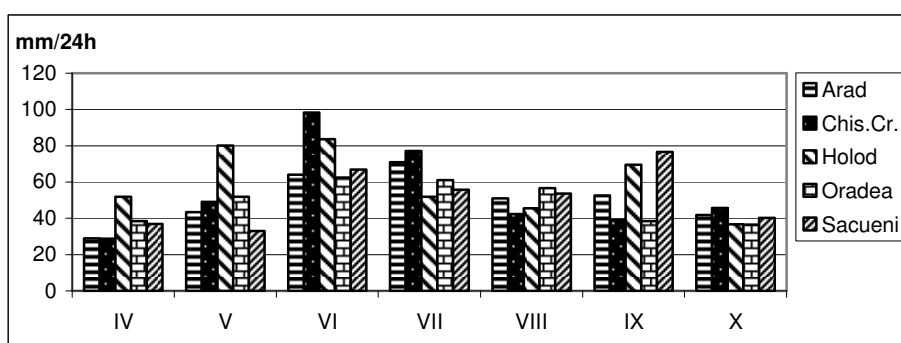


Fig.4 The variation of monthly maximum precipitation amounts within 24 hours in the Crisurilor Plain (1961-2000).

4. Hail

Over the Crisurilor Plain, the whole number of hail cases occurring during the warm period of the year is almost the same for all 4 stations with a longer observation period (Chisineu-Cris, Holod, Oradea, Sacueni), 31-34 cases. For the other 3 stations, with a shorter observation period, the number is also slightly different: between 12-15 cases (table 6).

Most of the days with hail are registered at the northern boundary of the plain, respectively Sacueni and Oradea – due to the higher air humidity – followed by the eastern boundary, at the contact with the hills (Holod). The constrained ascendant air movements, owed to the relief, amplify here the hail formation processes. The fewest days with hail occur in Ineu and Salonta, due to the lower altitude of the stations, less nebulosity and the short row of observation years.

During the warm period of the year, most days with hail produce in the interval **April-June** (30-40%) (fig.5). The phenomenon occurs due to the intense frontal activity specific to this time of year and in addition, to the thermic convection. Instead, the unfavorable interval for hail formation is **August-October** (0-12%). The cause stands in the persistence of the anticyclonic regime and low air humidity (August), respectively the air temperature drop (the interval September-October) which drives to the diminution of the thermic convection.

The total number of days with hail, strong wind and squall, recorded in the Crisurilor Plain in the warm period (April-October) (1970-2002).

Table 6

Warm per.	Chis.Cr.	Siria	Ineu	Salonta	Holod	Oradea	Sacueni
Hail	31	15	12	13	32	33	34
Strong wind	48	138	4	6	90	25	13
Squall	16	21	5	8	75	51	15

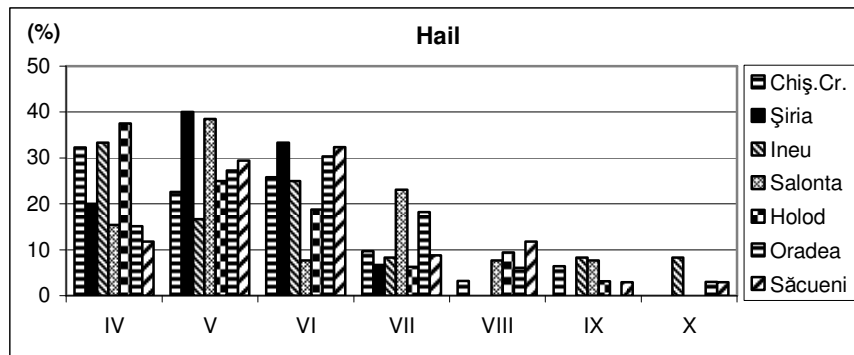


Fig.5 The frequency of days with hail in the Crisurilor Plain (1970-2002).

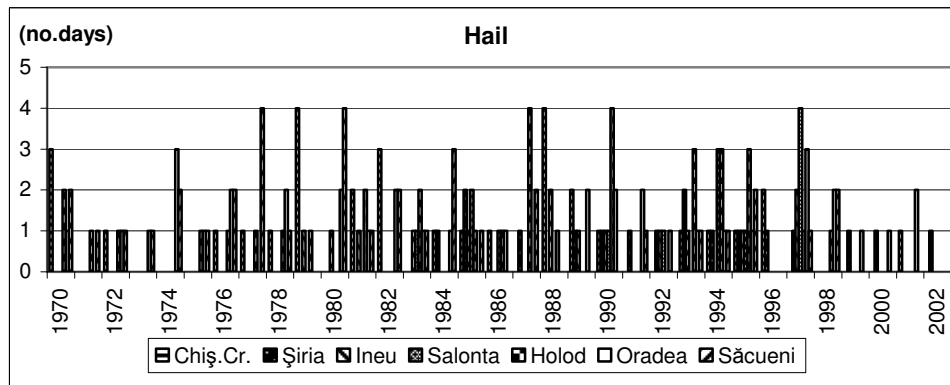


Fig.6 The annual number of days with hail in the Crisurilor Plain (1970-2002).

Along the years, the highest annual values were of 4 days with hail (fig.6). They were recorded at the stations Sacueni, Holod, Salonta and Chisineu-Cris. The figure shows that over the entire analyzed period, only 2 phenomenon decreasing periods occurred: 1971-1973 and 1999-2002. Beside that, the distribution of the days with hail was quite even. 1997 was the year with most cases of hail. We can say that in the last years this phenomenon became more rare.

5. Strong wind

Most of the days with strong wind (speed ≥ 16 m/s) are reported at Siria Station (a total of 138 cases in 19 observation years) (table 6), as it is located in the immediate vicinity of the

southern boundary of the Crisurilor Plain, in the mountainous space. Consequently, wind speed increases a lot here. High values of the phenomenon are also reported at the stations Holod (90 cases) and Oradea (25 cases) as they are located at the entry into the gulf depressions along which air flows are driven. High values are also reported at Chisineu Cris (48 cases) although it is located in the low land of the alluvial plain. The fewest cases are reported at the stations Ineu and Salonta, because of their lower altitude and also the short row of observation years.

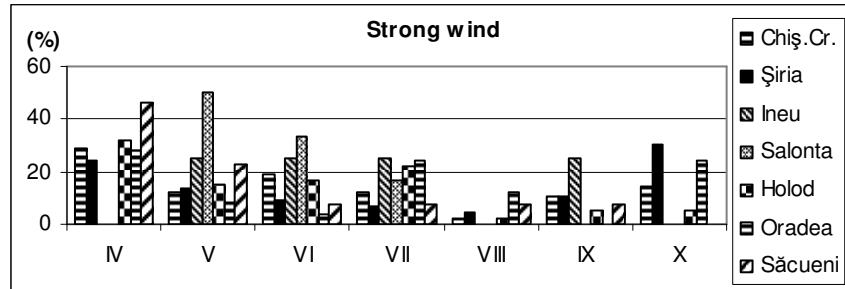


Fig.7 The frequency of days with strong wind in the Crisurilor Plain (1970-2002).

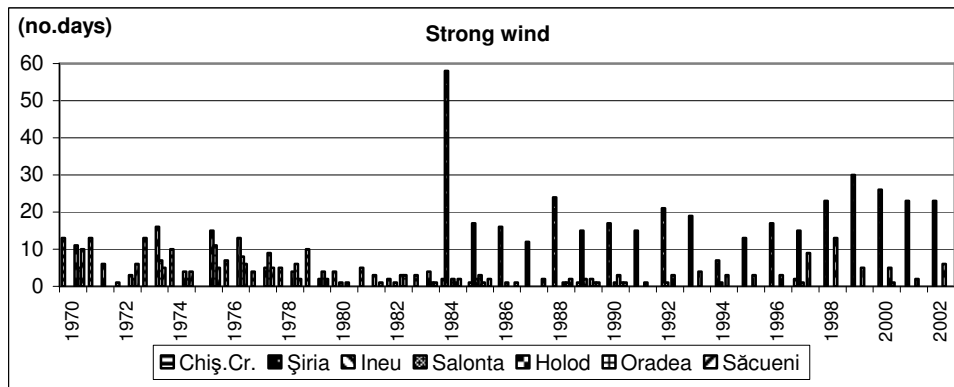


Fig.8 The annual number of days with strong wind in the Crisurilor Plain (1970-2002).

Along the warm period of the year, the highest frequency of strong winds occurs in *April* (25-46%) and only in the mountainous space in *October* (30% at Siria) (fig.7) that is during transition seasons when advections of cold air masses may occur. High frequency values are reported in May (Salonta 50%) or June-July, interval in which the air masses dynamics are more emphatic as a result of mountain-plain baric contrasts.

The minimum of the days with strong wind is recorded in *August* (0-12%) (in the north of the plain in September-October), when anticyclonic baric situations, with frequent calm air, prevail.

Figure 8 shows that values recorded at Siria Station exceed considerably the values recorded at the other stations. This situation is due to the higher altitude of the station, its location in the mountainous space where wind speed increases. The annual maximum value is 58 cases for 1984. There are no reports of years without cases of strong wind at this station. It has an aeolian energetic potential worth to be used.

Generally speaking, all stations report a great number of cases of strong wind at the beginning of the analysis period, during the decade **1970-1979**, then, the annual number of cases decreases between 1980-1990 and starting with 1991 it falls off, many stations recording no cases of strong wind (0 or maximum 1-2 cases in some of the years). Siria and Holod Stations are the only ones that make an exception. At Siria Station there are records of a few periods with

more cases (1992-1993 and 1998-2002, as well as the years 1984 and 1988) with more than 20 cases/year. At Holod Station, which is located at the contact of the plain with the Western Hills, cases of strong wind are recorded as well after 1990, more intense in the interval 1997-2002.

6. Squall

Most cases of squall are recorded for the stations located at the limit of the Crisurilor Plain with the Western Hills. Thus Holod Station has the highest risk degree for this kind of phenomena (75 cases) (table 6), followed by Oradea Station (51 cases) and Siria (21 cases; we have to note that at Siria Station the observation period is shorter). These high values occur due to the relief, so the stations Chisineu-Cris and Sacueni, located on the low alluvial plain, report medium values. The stations Ineu and Salonta report the lowest values as they are located at lower altitudes and their observation period is shorter.

Along the warm period of the year, most cases of squall are recorded in **July** (fig.9), when baric contrasts between the cold air masses in advection and hot, quasi-stationary masses are great. Consequently, between 2 cases may occur in Salonta and up to 27 cases in Holod, in this month. Most cases report again, at the eastern stations Holod (27), Oradea (19) and Siria (9). Sometimes the most squall cases may occur in the interval *May-July*. So, Chisineu-Cris reports the maximum in May, Ineu in June and Salonta in the interval May-July.

The fewest squall cases are recorded for the transition months *April* and *October* (0-3 cases), sometimes in September or May (0 cases in May at Ineu and Holod Stations) when the spatial baric differences are small.

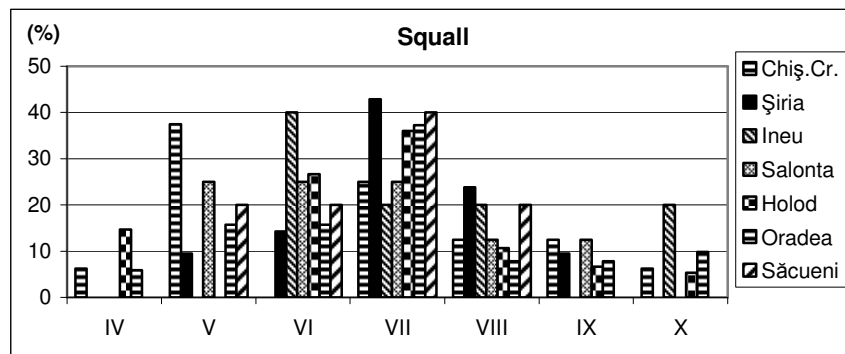


Fig.9 The frequency of days with squall in the Crisurilor Plain (1970-2002).

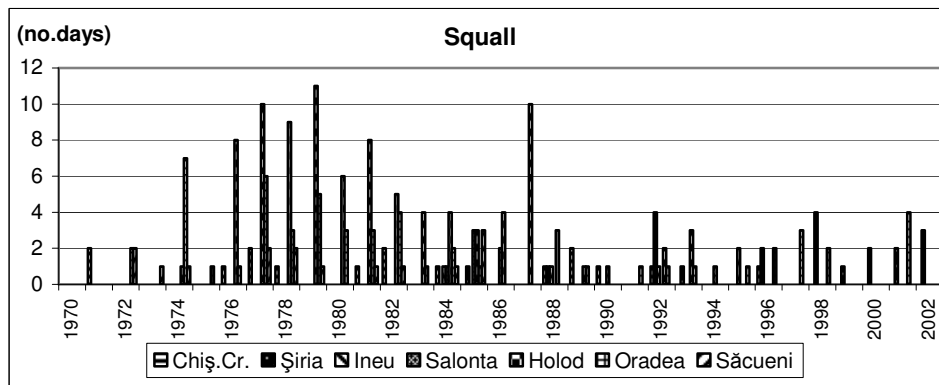


Fig.10 The annual number of days with squall in the Crisurilor Plain (1970-2002).

Along the years, great differences may be noticed in the distribution of squall cases (fig.10). Most of the cases were recorded in the interval **1974-1988** for most stations then they diminish a lot after 1988 (0 cases in most of the years or, maximum 1-4 cases in some years). The only exception is Siria Station that shows a concentration of squall cases between 1992-1993 and 1998-2002. But it is worth mentioning that this station's observation period only started in 1984 and it is located in different, mountainous relief conditions.

The maximum annual value recorded was 11 cases for Holod Station in 1979, followed by 10 cases in 1977 and 1987. Moreover, this station reports most of the annual squall cases, followed by Oradea Station.

Conclusions

In the Crisurilor Plain, the absolute maximum temperatures occur in August. The Plain is under an autumn and a spring drought, but the phenomenon may occur in any month of the year. The maximum diurnal precipitation amounts – with an impact upon vegetation, elutriation and river discharge – are more frequent in June-August interval.

Hail mostly affects the northern part of the plain and the eastern one, at the contact with the hills. It generally occurs in the interval April-June. Strong winds are mostly recorded in the high regions (Siria), with a high frequency in April, and squalls mostly affect the contact space of the plain with the hills, the highest frequency being recorded in July.

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