

Wind Frequency in Vojvodina's Part of Banat

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Abstract *The Vojvodina's part of Banat spreads through the eastern part of Vojvodina. For the analysis of wind frequencies we took the data from eight meteorological stations. We have analysed the data according to seasons and for the entire year. The winds from south-eastern (211 ‰) and north-western (148 ‰) direction have the highest average frequencies. The wind from south-eastern direction – Kosava, has the highest frequency during the winter, spring and autumn, while in summer the most frequent wind is northwesterly. At the same time, most calm periods appear in summer. The highest frequency of winds is found in Northern Banat, then in the Central Banat, and the Southern Banat has the smallest wind frequency (248 ‰ calm period annually).*

Key words wind, frequency, Banat, Vojvodina

Position

Yugoslav part of Banat stretches along the eastern part of Vojvodina. In the north-south direction its position is between the Mures and the Danube rivers, and in the west-east direction between the Tisza river and the state border of Romania. The examined area occupies the area in the central part of mild climatic zone, significantly distant (about 2,000 km) from the main source of humidity, the Atlantic Ocean. At the same time, Banat is isolated from direct penetration of the cold, continental air, by the Carpathian Mountains and it penetrates only under special weather conditions. Closer to Banat is a smaller aquatic territory, the Mediterranean. However, the existence of a strong mountain barrier as the Dinaric Alps extending vertically to the direction of southern winds modifies the influence of the aquatic territory.

Method

In the research of wind frequency in Banat, data from eight meteorological stations were used, where data from seven stations are in the period 1951-1990, whereas the station Jasa Tomic gives data for the period 1954-1990. Firstly, frequency and stillness of winds will be analyzed at all stations, then in separate climatic regions and finally for the whole territory of Banat by seasons and for one year period.

List of meteorological stations and their positional characteristics, starting from the northernmost:

- Senta: 45°56' North Latitude and 20°05' East Longitude, altitude 80m
- Kikinda: 45°51' North Latitude and 20°27' East Longitude, altitude 81m
- Jasa Tomic: 45°27' North Latitude and 20°51' East Longitude, altitude 81m
- Zrenjanin: 45°24' North Latitude and 20°25' East Longitude, altitude 80m
- Vrsac: 45°09' North Latitude and 21°19' East Longitude, altitude 84m
- Susara: 44°56' North Latitude and 21°08' East Longitude, altitude 180m
- Bela Crkva: 44°54' North Latitude and 21°25' East Longitude, altitude 90m

- Pancevo: 44°53' North Latitude and 20°40' East Longitude, altitude 80m

Wind, together with air temperature and pressure, presents an important element of climate. Due to air movements, maritime and continental air masses exchange, i.e. air masses from different latitudes and longitudes, which differ in temperature and humidity. Thus, carrying climatic features of the area they originate, the winds strongly influence certain areas and take the role of climate modifier.



Fig 1 Positions of meteorological stations in Vojvodina's part of Banat

According to relatively small area of Banat and rather balanced air pressure, there are no significant air currents of local importance between parts of the research-covered area. However, on the territory of Banat, and broader area of the Pannonian Basin, there are very frequent air movements caused by barometric difference between large aquatorias of The Atlantic and the Mediterranean on one hand and on the other Euro-Asian land on the other. Due to the present distribution of air activity centers on the territory of Pannonic plain, the dominating winds come from the western, or the eastern quadrant.

Wind frequency

Winter

The table 1 gives data on winter wind frequency and calmness for the observed period in eight (8) meteorological stations, by separate climatic regions and for Banat as a unit.

In Winter, the most of the territory in Banat is dominated by the southeast wind, what is the consequence of the distribution of barometric depressions in the west part

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of the Mediterranean on one hand and on the other the anticyclone above the south parts of Ukraine and Besarabia. Thus, Kosava is the wind of the highest frequency (table 1) at seven stations. Frequency of southeastern wind at these stations ranges between 185‰ (in Bela Crkva) to 318‰ (in Susara). In Senta, the most frequent is northwestern wind with 195‰. It is significant that apart from southeastern and northwestern winds, there is also dominating southern wind (especially in Kikinda, Zrenjanin, and Pancevo).

The lowest frequencies in a large portion of Banat belong to the eastern wind. Its minimal frequency occurs at six stations (37‰ in Vrsac and 62‰ in Zrenjanin). In Susara, the lowest frequency is recorded for northeastern and southern wind (25‰), and in Bela Crkva for north-eastern wind (26‰).

The highest calmness during winter occurs at four southern Banat stations, where Bela Crkva (348‰) and Susara (309‰) are singled out. Opposite to southern, northern and central parts of Banat represent rather windy areas with relatively small calmness (from 59‰ in Zrenjanin to 77‰ in Senta).

All three climatic regions (table 1) are dominated during winter by the wind – Kosava. The highest frequency of this wind occurs in Central Banat (255‰), slightly lower in Southern (234‰), and the lowest in Northern (201‰). Apart from the southeastern wind, in all three climatic regions the frequencies of northwestern and southern wind are significant.

The lowest frequency in northern, central, and southern observed parts of Banat is recorded for eastern wind (in South Banat 43‰, in Central 52‰, and in North 57‰). Low frequencies are recorded for northeastern and southwestern wind. The lowest occurrence of wind during winter is in South Banat, which is supported by the high value of calm 246‰. Fare more windy are North (calm is 68‰) and Central Banat (calm is 63‰).

Observing the whole of Banat (table 1), it is noticeable that the most dominating is southeastern wing with frequency of 227‰, and the least eastern wind with frequency values of only 48‰ (graph 53).

The high frequency is recorded with winds from southwestern (135‰) and southern direction (127‰), whereas low frequency characterizes northeastern (62‰) and southwestern winds (67‰). Calmness for the total Banat is 157‰.

Spring

During spring then distribution of dominating winds undergoes slight changes. Namely, in comparison to the winter period increased frequency of northwestern wind is observed, which is yet less frequent than southeastern wind, whereas at the same time, in most of the cases calm-

■ **Table 1** Average winter frequencies of winds and calms (‰) in Banat in the period 1951-1990.

Winter	N	NE	E	SE	S	SW	W	NW	C
Senta	118	78	58	177	107	80	110	195	77
Kikinda	117	81	51	196	171	88	103	125	68
Jaša Tomić	119	91	42	281	101	83	66	151	66
Zrenjanin	89	74	62	230	152	63	141	130	59
Vršac	88	63	37	222	207	74	75	77	157
Šušara	40	25	37	318	25	29	51	166	309
Bela Crkva	52	26	67	185	52	41	70	159	348
Pančevo	87	62	30	210	198	76	88	79	170
North Banat	108	78	57	201	143	77	118	150	68
Central Banat	104	82	52	255	127	73	103	141	63
South Banat	67	44	43	234	121	55	71	120	246
Banat	89	62	48	227	127	67	88	135	157

Source: Meteorological yearbooks 1951-1990.

ness becomes lower (table 2). Thus, on the observed stations still the most dominant are southeastern and northwestern winds, whereas the lowest frequency in most of the cases is recorded for the winds of eastern, southern and northeastern direction.

At seven meteorological stations, the most frequent is southeastern wind. As in winter, it is only in Senta where the highest frequency is recorded for northwestern wind. Among those seven stations, the highest frequency, 302‰, is recorded for southeastern wind in Susara, and the lowest, 184‰, in Kikinda. In Senta northwestern wind (188‰) is more dominant than southeastern (165‰) for 23‰. The lowest frequency in Susara (18‰) is recorded for southern wind, and in Bela Crkva eastern and northeastern with identical values of 29‰. All other stations record the lowest frequency of eastern wind. The least windy in spring are Bela Crkva and Susara, and the windiest are Kikinda, Zrenjanin and Senta. This is supported by the value of calm, which is 309‰ for Bela Crkva, 242‰ for Susara, whereas in Kikinda its value comes to only 52‰, in Zrenjanin 55‰, and in Senta 57‰.

Observing average frequencies by climatic region it is possible to understand that in all three regions the southeastern wind is

the most dominant, then follows northwestern, and then with lowest frequency eastern wind, and then winds from northeastern and southwestern directions.

The highest frequency is recorded for southeastern wind in Central Banat (249‰), then in South Banat (234‰), and the lowest in North (189‰). Northwestern wind, observed regionally, shows noticeable standardized frequency. Namely, it is the most frequent in southern (172‰), slightly lower in northern (162‰), and the lowest in central (159‰) part of the observed area. It is also important to emphasize that the north wind is frequent too, especially in the north and central parts of Banat.

Eastern wind, which is of far lowest frequency, reaches its minimum in South Banat (41‰), slightly higher in Central (48‰) and the highest in North (57‰). As it has been quoted here, relatively low frequencies characterize northeastern and southwestern winds.

The most windy parts are the north parts of Banat where the value of calm is only 55‰, central parts follow immediately with calm 65‰, whereas the least windy parts are those in the south of the observed area where the frequency is the highest (199‰).

■ **Table 2** Average spring frequencies of winds and calms (‰) in Banat in the period 1951-1990.

Spring	N	NE	E	SE	S	SW	W	NW	C
Senta	145	84	57	165	113	90	101	188	57
Kikinda	138	93	55	184	124	96	98	160	52
Jaša Tomić	121	86	38	282	73	88	57	180	75
Zrenjanin	123	72	58	217	134	73	130	138	55
Vršac	101	90	39	221	159	72	83	101	134
Šušara	40	30	45	302	18	30	69	224	242
Bela Crkva	61	29	29	192	61	58	87	174	309
Pančevo	103	79	49	223	90	57	99	190	110
North Banat	135	83	57	189	124	86	110	162	55
Central Banat	122	79	48	249	103	81	94	159	65
South Banat	76	57	41	234	82	54	85	172	199
Banat	104	70	46	223	97	71	91	169	129

Source: Meteorological yearbooks 1951-1990.

Table 3 Mean summer wind frequency and calm (%) in Banat for the period 1951-1990.

Summer	N	NE	E	SE	S	SW	W	NW	C
Senta	129	89	53	133	100	85	121	192	98
Kikinda	130	97	58	145	92	79	117	187	95
Jaša Tomić	127	81	48	179	65	85	65	225	125
Zrenjanin	127	80	58	141	104	73	163	174	80
Vršac	116	80	43	138	134	80	94	123	192
Šušara	83	54	39	129	79	79	114	123	300
Bela Crkva	51	29	36	103	40	54	123	160	404
Pančevo	97	73	48	151	122	91	100	118	200
North Banat	129	89	56	140	99	79	134	184	91
Central Banat	127	80	53	160	84	79	114	200	103
South Banat	87	59	41	130	94	76	108	131	274
Banat	107	73	48	140	92	78	112	163	187

Source: Meteorological yearbooks 1951-1990.

On the area of the whole Banat (table 2) the most dominant are southeastern (223%), and northwestern winds (169%), and the least frequent winds from the eastern (46%), northeastern (70%), and southwestern (71%) directions. The number of calmness is significant - 129%.

Summer

Highly noticeable changes in wind frequency distribution are recorded during summer in comparison to winter and spring period, what primarily refers to significant increase in northwestern and decrease in southeastern wind occurrence. According to Katic et al (1979), this is the consequence of high air pressure values above the Atlantic Ocean and low air pressure values above Central Asia, as well as of frequent passes of barometric depressions above the Adriatic and Mediterranean.

Thus, at five measure stations (Senta, Kikinda, Jaska Tomic, Zrenjanin, and Bela Crkva) the highest occurrence is recorded for northwestern wind, whereas at other three measure stations (Vrsac, Susara, and Pancevo) it is recorded for southeastern wind well known as Kosava (table 3). Northwestern wind frequency values at five-mentioned measure stations range from 160% (Bela Crkva) to 225% (Jaska Tomic), whereas southeastern wind frequency values range from 151% (Pancevo), 138% (Vrsac) to 129% (Susara). It is important to emphasize that apart from those winds rather frequent distribution is recorded for winds of north and west directions.

The lowest frequency rate, which is the same as in two earlier seasons, are recorded even at seven measure stations for eastern wind (ranging from 39% Susara, to 58% Kikinda and Zrenjanin). It is only in Bela Crkva where the lowest occurrence rate is recorded for northeastern wind (29%) which is 7% less than recorded for the eastern wind. During summer, other winds of relatively low frequency are recorded at measure stations, e.g. south-

western wind (Senta, Kikinda, Zrenjanin) and western (Jaska Tomic).

The significant feature of summer period is increase in calmness, which, during this warmest season in Banat, ranges from 80% (Zrenjanin) to remarkably 404% (Bela Crkva).

There are no significant deviations by climatic regions (table 3). The most dominant winds in all three regions are northwestern, then follow southeastern, whereas the lowest frequency in all three regions is recorded for eastern wind, and then for winds from southwestern and northeastern directions.

The highest frequency of 200% is recorded for the northwestern wind in Central Banat, whereas in North Banat frequency of this wind is 184%, and in South Banat 131%. Southeastern wind, which lags behind the northwestern in frequency value, has the same frequency distribution by climatic regions. Namely, its frequency in Central Banat is 160%, in North Banat 140%, and in South 130%. Also, north and west winds have significant frequency distribution in North and Central Banat.

East wind, which is the most rare during this season, records the lowest frequency in South Banat (41%), slightly higher in Central (53%) and North Banat (56%).

During summer, South Banat with calm of 274% represents the part of the

researched area with lowest wind frequency. Windier are Central (calm 103%) and northern parts of Banat (calm 91%).

On the whole region of Banat (table 3), the most prevailing winds are northwestern (163%) and southeastern (140%) winds, whereas the lowest frequency is recorded for eastern wind (48%). Low distribution is recorded for northeastern (73%) and southwestern (78%) winds.

Autumn

During autumn, the distribution of anticyclone and cyclone in broader district is such that again on the territory of Banat the most frequent is southeastern wind, far more than during winter and spring (table 4). All eight measure stations record the dominance of southeastern wind. Its frequency ranges from 206 % (Senta) to 333% (Susara). The second place in frequency is shared between northwestern (Senta, Jaska Tomic, Susara, Bela Crkva, and Pancevo) and southern (Kikinda, Zrenjanin, and Vrsac) winds. According to earlier researches (Katic et al. 1979) southern wind in Banat in winter shows higher frequency distribution in comparison to other seasons.

Eastern wind is the least frequent in autumn in most of Banat. Namely, in Senta (62%), Vrsac (44%), and Pancevo (332%) the lowest frequencies were recorded, whereas at measure station Jaska Tomic together with western wind (53%), and in Zrenjanin (66%) together with southwestern wind it records the lowest frequency. In Kikinda (64%) and Bela Crkva (22%), the lowest frequency was recorded for northeastern, and in Susara (22%) southern wind. It is also important to say that at measure stations of South Banat, apart from southeastern, in Susara apart from northwestern, and in Pancevo apart from southern winds, the winds from other directions recorded extremely low frequencies. Here calms are rather frequent and range from 160% in Vrsac to 421% in Bela Crkva. Calms in the northern and Central parts of Banat are of significantly lower frequency, which rang-

Table 4 Mean autumn wind frequency and calm (%) in Banat for the period 1951-1990.

Autumn	N	NE	E	SE	S	SW	W	NW	C
Senta	109	74	62	206	123	81	101	178	66
Kikinda	116	64	66	231	144	85	94	130	70
Jaša Tomić	100	94	53	295	79	81	53	155	90
Zrenjanin	92	70	66	245	147	66	128	121	65
Vršac	88	73	44	244	172	62	73	84	160
Šušara	33	29	55	333	22	26	44	139	319
Bela Crkva	33	22	59	208	48	44	77	88	421
Pančevo	51	63	32	270	190	60	53	91	190
North Banat	106	69	65	227	138	77	108	143	67
Central Banat	96	82	59	270	113	73	91	138	78
South Banat	51	47	47	264	108	48	62	100	273
Banat	78	61	55	254	116	63	78	123	172

Source: Meteorological yearbooks 1951-1990.

es from 65‰(Zrenjanin) to 90‰ (Jasa Tomic).

In all three climatic regions (table 4) the most dominant is southeastern wind, whereas winds from eastern and north-eastern direction blow quite rarely. South-eastern wind records the highest frequency in Central Banat (270‰), in Southern Banat 6‰, less which is (264‰), and the least in the northern part of the area covered by the research (227‰). By the frequency of occurrence right behind south-eastern wind in North and Central Banat, there is the wind from northwestern, and in South Banat the wind from southern direction.

The lowest frequency rate of 47‰ is recorded for eastern wind, together with western in the southern part of Banat, whereas in the central area (59‰) and in the northern parts (65‰) of the researched area eastern wind occupies the last place by frequency. It is easily observed that in South Banat, winds from directions other than southeast, partly south and northwest are of low distribu-

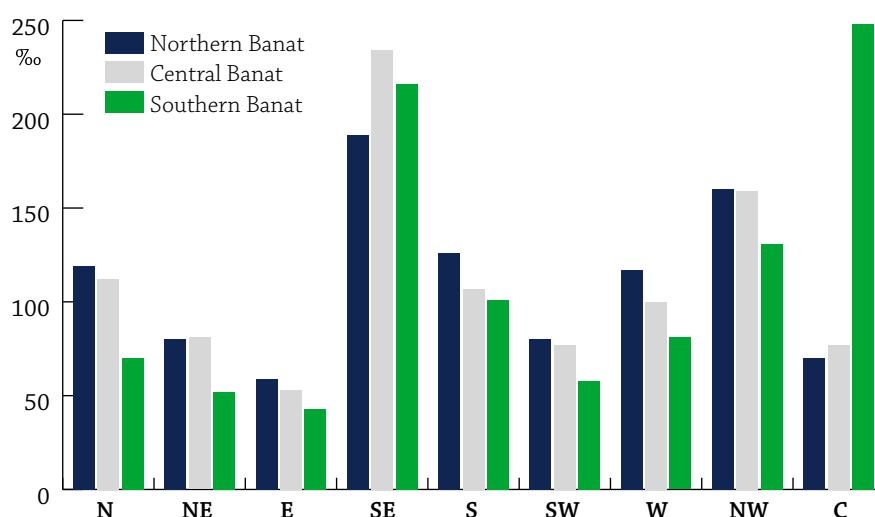


Fig 2 Average annual winds and calm periods (%) for the Northern, Central and Southern Banat in the period 1951-1990.

According to data in table 5, on the whole area covered, the most dominant are winds from southeastern and northwestern direction, whereas the least frequent are winds from eastern and northeast-

frequency of 188‰ (southeastern wind in Senta is less frequent than northwestern wind for 18‰). It is important to emphasize that in Vrsac (168‰) and in Pancevo (150‰), the occurrence of southern wind is rather frequent.

At six measure stations the least frequent are the winds from eastern direction (40‰ in Pancevo and 61‰ in Zrenjanin), and northeastern direction (34‰ Susara and 27‰ Bela Crkva). Besides the aforementioned, relatively low frequency is recorded for southwestern (Zrenjanin, Vrsac), southern (Susara) and western (Jasa Tomic) winds.

The highest frequency of mean annual calm is recorded at measure stations in the south of Banat (from 161‰ in Vrsac to 371‰ in Bela Crkva), whereas calm at stations in North and Central Banat far less frequent and its occurrence ranges from 65v (Zrenjanin) to 89‰ (Jasa Tomic).

The highest mean annual frequencies in all three climatic regions (table 5) belong to southeastern and northwestern winds. The lowest mean annual frequencies belong to eastern, southwestern and north-eastern winds.

Table 5 Mean annual wind frequency and calm (%) in Banat for the period 1951-1990.

Annual	N	NE	E	SE	S	SW	W	NW	C
Senta	125	81	58	170	111	84	108	188	75
Kikinda	125	84	58	189	133	87	103	150	71
Jaša Tomić	117	88	45	259	80	84	60	178	89
Zrenjanin	108	74	61	208	134	69	140	141	65
Vršac	98	77	41	206	168	72	81	96	161
Sušara	49	34	44	270	36	41	70	163	293
Bela Crkva	49	27	48	172	50	49	89	145	371
Pančevo	84	69	40	214	150	71	85	119	168
North Banat	119	80	59	189	126	80	117	160	70
Central Banat	112	81	53	234	107	77	100	159	77
South Banat	70	52	43	216	101	58	81	131	248
Banat	94	67	49	211	108	70	92	148	161

Source: Meteorological yearbooks 1951-1990.

tion. As it has already been said, calms are the most frequent here (273‰), whereas in the central (78‰) and in northern (67‰) parts of the researched area they are of lower frequency. On the whole territory of Banat (table 4), according to expectations, the most dominant is the southeastern wind (254‰), then follow winds from northwestern direction (123‰), and southern (116‰) direction. Conversely, the lowest frequency shows eastern (55‰), northeastern (61‰), and southwestern (63‰) winds (graph 59). The average calm for the whole Banat is 172‰.

Annual

Mean annual wind frequency and calm in Banat represent the result of the existing view of frequency and clam by seasons. On the basis of annual mean values it is difficult to define the correlation between frequency of winds from different directions, as well as frequency of calm by seasons, which undoubtedly exist.

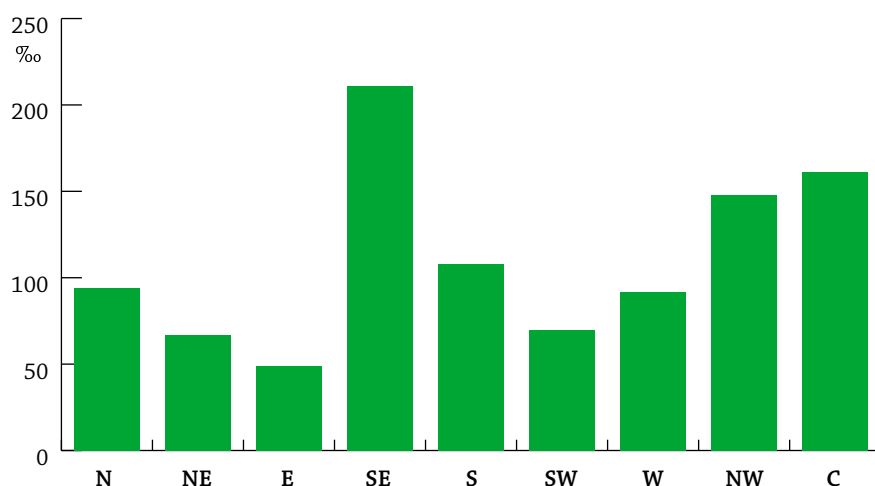


Fig 3 Average annual winds and calm periods (%) for Banat in the period 1951-1990.

Southeastern wind shows the highest frequency in Central Banat (234‰), slightly lower in South (216‰), and the lowest in North (189‰). Annual frequencies of northwestern wind gradually decrease from southwards (from 160‰ to 131‰). Significant frequency of occurrence in North and Central Banat is recorded for winds from north and west direction.

Eastern wind shows the lowest frequency in all three regions and its values decrease southwards (from 59‰ to 43‰). Low frequency, especially in South Banat, is recorded for northeastern (52‰) and southwestern (58‰) winds. The highest annual calm is recorded for southern parts of Banat (248‰), whereas in Central (77‰) and in North Banat (70‰) the value of calm is lower.

On the whole area of Banat the highest mean annual frequency (table 5) is recorded for winds from southeastern (211‰) and northwestern (148‰) directions, and the lowest mean annual frequency is recorded for winds from eastern (49‰), northeastern (67‰) and southwestern (70‰) direction. The value of mean annual calm is 161 ‰.

Conclusion

Analyzing the data, it is possible to say that during the year on the whole territory of Vojvodinian part of Banat, the winds of highest frequency are those from southeastern (211‰) and northwestern (148‰) quadrant. The wind from the southeastern quadrant - Kosava has the highest frequency value during winter, spring, and autumn, whereas in summer the most frequent wind is that from northwestern

quadrant. At the same time, the highest calm occurs during the summer period.

The highest wind frequency was recorded for North Banat, then for Central Banat, and the lowest values were recorded for South Banat (248‰ annually).

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