

UDK 551.515.9(477.75)

THE REVIEW OF NATURAL HYDROMETEOROLOGICAL PHENOMENA WITHIN REGION OF NIKITSKY BOTANICAL GARDENS

KORSAKOVA S.P.

Nikitsky Botanical Gardens – National Scientific Centre, the city of Yalta

Introduction

Hydrometeorological phenomena are characterized as natural (elemental) hydrometeorological phenomena (NHP) if they reach definite values of intensity, duration, emergence time and can cause damage for economy and threat to human security. Natural hydrometeorological phenomena are the most dangerous result of climate instability. Being climatic extrema, they influence on the long-term weather patterns of a region. In recent years due to considerable climate fluctuations, a number of NHP in Russia and Ukraine has increased and mostly they become catastrophic with large-scale material losses for a state economy and even human victims [6, 7]. As a rule, NHP emerge in complex, what aggravates their negative effect: heavy showers are accompanied by storm wind, squall, hail; blizzards are accompanied by snowfall and high wind, sleet and ice formations and etc. Each month, season, period and year is characterized by a definite type of the natural phenomenon or a complex of phenomena, caused by anomalous circulation processes taking place in atmosphere and meteorological conditions [4].

South Coast of the Crimea isn't a high risk area, though elemental hydrometeorological phenomena are registered annually here. Some of such phenomena occur almost every year (abundant rainfall, wind). Probability of others is too low (tornado, blizzards). Nevertheless integrated study of dangerous weather phenomena dynamics and analytical summarizing of NHP expectancy is a base to assess meteorological risk in this area.

At present agrometeorological station "Nikitsky Garden" possesses observation data for 85 years period, which will make it possible to generalize, retrace dynamics, some regularity and peculiarities of NHP emerge on South Coast of the Crimea in the region of Nikitsky Botanical Gardens.

The research objective is a complex study of dynamics, NHP mapping during a year and probability of their occurrence in the region of Nikitsky Botanical Gardens with further assessment of meteorological risks on this territory.

Objects and methods of the research

Data of agrometeorological station "Nikitsky Garden" (situated on the territory of Nikitsky Botanical Gardens), including a number of observations, were used during this research. Observation period for principle meteorological elements makes 85 years (1930 – 2014). To describe frequency and time-space distribution of storm winds on the area of Big Yalta, information of 1869 -1961 period (generalized by staff of marine hydrometeorological station "Yalta" and presented in the work "Hydrothermal regime of South Coast of the Crimea") was used [2].

Documents of Goscomhydromet USSR, Ukrainian GMC and Roshydromet served as the base of criteria for natural hydrometeorological phenomena (RD 52.3.2.03.-13, RD 52.04.563 – 2013).

Phenomena reaching definite values, capable to cause damage for economy and material loss are characterized as natural (elemental) hydrometeorological phenomena

(NHP): 1) wind (squall) with velocity of 25 m/s and more, 2) shower or an intensive rain, ≥ 30 mm per 1 hour or less, 3) heavy rain, ≥ 30 mm per 12 hours or less, 4) heavy snowfall, ≥ 20 mm per 12 hours or less, 5) air temperature pull down till -10°C and below within South Coast of the Crimea (SCC), 6) hail, 20 mm across diameter and bigger, 7) worsening of horizontal visibility (because of fog, blizzard) till 100 m for 12 hours and longer, 8) hot dry wind, 9) blizzard or duststorm with wind velocity of ≥ 15 m/s for 12 hours and longer, 10) increasing of the air temperature on SCC till 40°C and higher, 11) ice-covered ground with formation of ≥ 20 mm, 12) sleet formation of ≥ 35 mm.

Physiographic position of South Coast of the Crimea and the Crimean Mountains underlie formation of synoptic processes, causing dangerous natural phenomena. On Nikitsky Botanical Gardens area since 1930-2014 it was registered 330 cases of weather phenomena that reached criterion of NHP, set for this territory. Average number of such phenomena annually is 4. The most frequent phenomena as follows: heavy rains, strong wind and air temperature pull down till -10°C (Fig.1). For this period, 137 cases (42% of total NHP, emerged on the area of Nikitsky Botanical gardens) of heavy rain and 132 cases (40%) of heavy wind were registered (table 1). Air temperature pull down till -10°C were fixed 35 times (11%). In recent 85 years of meteorological observations in Nikitsky Botanical Gardens it was registered 5 cases of heavy shower and 7 showfalls (see table 1). In this period on South Coast of the Crimea, regular air temperature increasing in summer causes precipitation reduction in June and August. In combination with high summer temperature it calls more dry phenomena, decreasing crop capacity of SCC agriculture. Concerning above-mentioned period, hot dry wind was registered in August 1971, July 1999 and July-August 2007. Heavy hail emerges rarely: July the 8th 1977, July the 15th and August the 29th in 2006. Hailfall was lasting for about some minutes, but economy of SCC got huge losses. Size of hailstones reached 20-25 mm across diameter; some of them were 30 mm each. For last 25 years on the area of SCC long-term cases of fog were registered with horizontal visibility of 100 m/12 hours and longer: March the 25th 1990 and May the 8th 2006. Long-lasting blizzards with horizontal visibility of 100 m lasting for 12 hours weren't registered on South Coast of the Crimea. Since 1930 till present only watersprouts were fixed (13.08.1987). Cases of tornado weren't recorded.

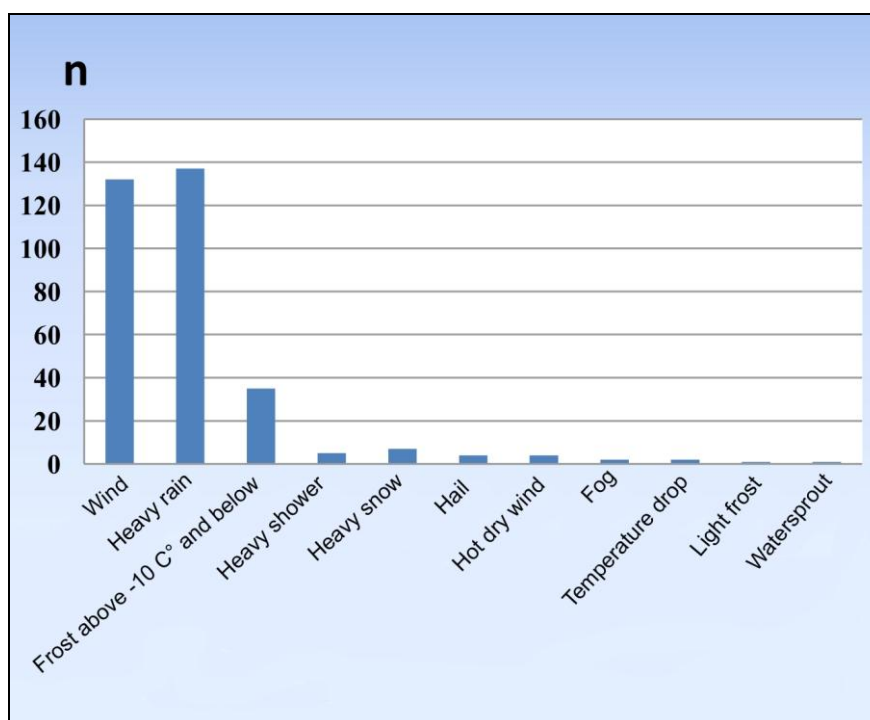


Fig.1 Types and number (n) of natural hydrometeorological phenomena, registered on the area of Nikitsky Botanical Gardens during 1930 – 2014 period.
(Not considering anomalously hot/cold weather and extremely fire hazard)

Table 1

Number of natural hydrometeorological phenomena during 1930 – 2014 period and decades separately on the area of Nikitsky Botanical Gardens

Years	1930-1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2014	1930-2014
Wind ≥ 25 m/s	1	5	2	18	30	21	20	28	7	132
Heavy rain ≥ 30 mm per ≤ 12 h	20	9	15	17	15	20	19	19	3	137
Heavy shower ≥ 30 mm per ≤ 1 h	0	0	0	1	0	0	0	4	0	5
Frost $\leq -10^\circ\text{C}$	7	7	3	4	4	4	0	3	3	35
Heavy snowfall ≥ 20 mm per ≤ 12 h	0	0	0	2	0	1	1	1	2	7
Hail ≥ 20 mm	0	0	0		1	0	0	3	0	4
Fog < 100 m during ≥ 12 h	0	0	0	0	0	1	0	1	0	2
Hot dry wind	0	0	0	0	1	0	1	2	0	4
Watersprout	0	0	0	0	0	1	0	0	0	1
Hard frost	0	0	0	0	0	0	0	1	0	1
Temperature drop	0	0	0	1	1	0	0	0	0	2

Sharp reduction of daily average air temperature per a day within 10°C occurred twice: February the 26th and 27th in 1968, January the 12-13th in 1972.

In recent 85 years phenomena of hard frost, caused losses, was registered only once on the area of Nikitsky Botanical Gardens – at the beginning of April, 2004. Due to advection of cold polar air on South Coast of the Crimea air temperature below zero was keeping during 10 hours in April the 3rd. The frost was accompanied by northeast wind with velocity of

16m/s (by wind gust) and low relative humidity (35-39%). At night (April the 3-4th) advective frost was intensified by radiation cooling, minimal air temperature fell till $-5,5^{\circ}\text{C}$, temperature of soil surface went down till $-8,5^{\circ}\text{C}$.

Such intensive frosts hardly ever occur on the coast in the beginning of April. Before 2004 they were registered only in April the 3-4th in 1965, when minimum air temperature fell till $-5,7^{\circ}\text{C}$. The following should be mentioned there weren't any damages for fruit plants after this phenomena in 1965, as all cultures were in state of bud swelling or budbreak. In spring 2004, due to extremely warm weather almond, apricot and peach trees were in blossom, alycha shedded its blossom, fig tree was on the stage of budbreak and forming of infructescences of the first generation, grape vine was on the stage of mass bud swelling, some cultivars of grape vine had a budbreak. That's why frost in April the 3-4th in 2004 damaged all blossoming fruits completely. That year damage of grape vine reached 30-45%, yield of apricot, peach and alycha on South Coast of the Crimea was small or wasn't at all.

In period of 1930-2014 blizzard and duststorm with an average wind velocity of ≥ 15 m/s lasting for 12 hours or longer didn't occur. Maximum air temperature on the territory of Nikitsky Botanical Gardens wasn't higher than 39°C . Observation for ice-covered ground and sleet formation are not carried out.

To specify nature of elemental hydrometeorological phenomena changes, trends of all phenomena case number, recorded on Nikitsky Botanical Gardens area, were diagramed and analyzed. These diagrams include annual and 5-years periods data (Fig.2), and dominant phenomena (heavy wind and heavy rain,) information as well (Fig.3 – 4). The linear trend permits to investigate fluctuations in the middle of time line, tracing their interannual dynamics, which is characterized by alternation of increasing and decreasing periods. Increasing direction of the linear trend is caused by sophisticated interaction of atmosphere circulation, natural and anthropogenic aerosols, solar activity level, greenhouse gases [4]. Linear trend was counted in complex for all phenomena. It presents a tendency to increasing of the total number.

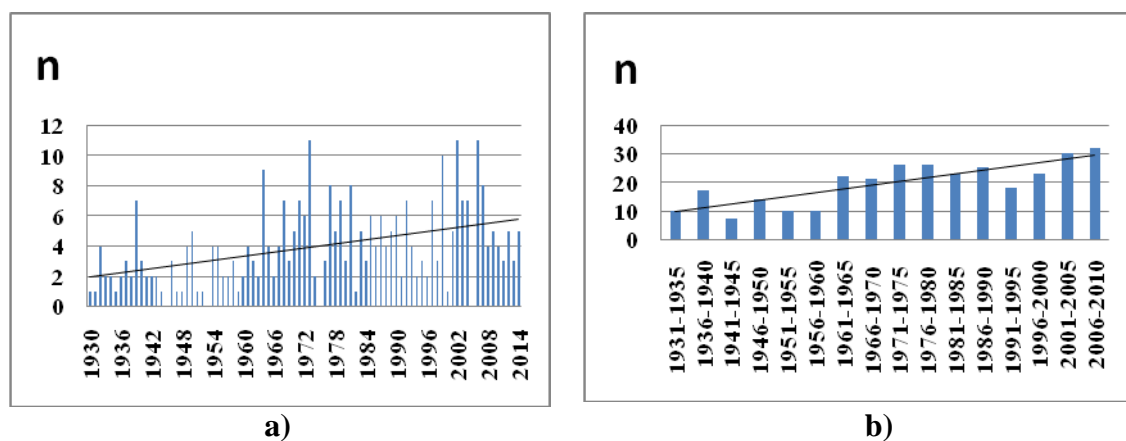


Fig. 2 Number of natural hydrometeorological phenomena cases (n) annually (a) and by 5-years periods in the region of Nikitsky Botanical Gardens (b)

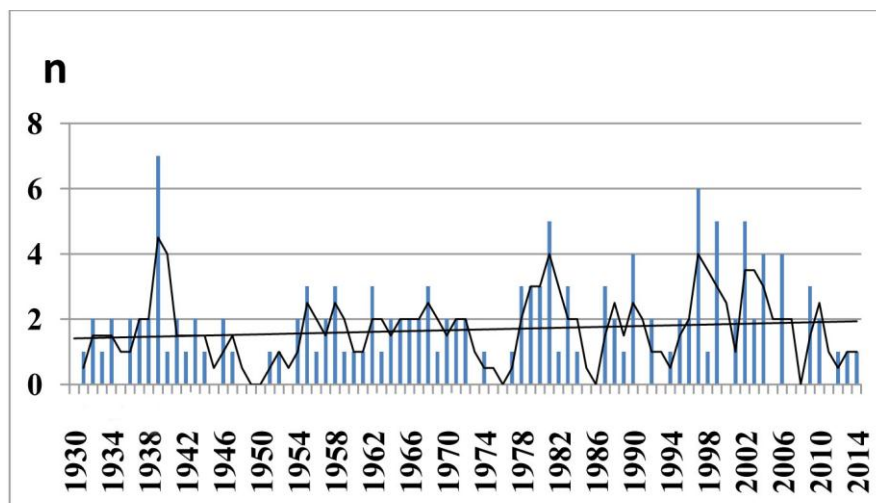


Fig. 3 Number of heavy rain cases (n), ≥ 30 mm per 12 hours and less in the region of Nikitsky Botanical Gardens

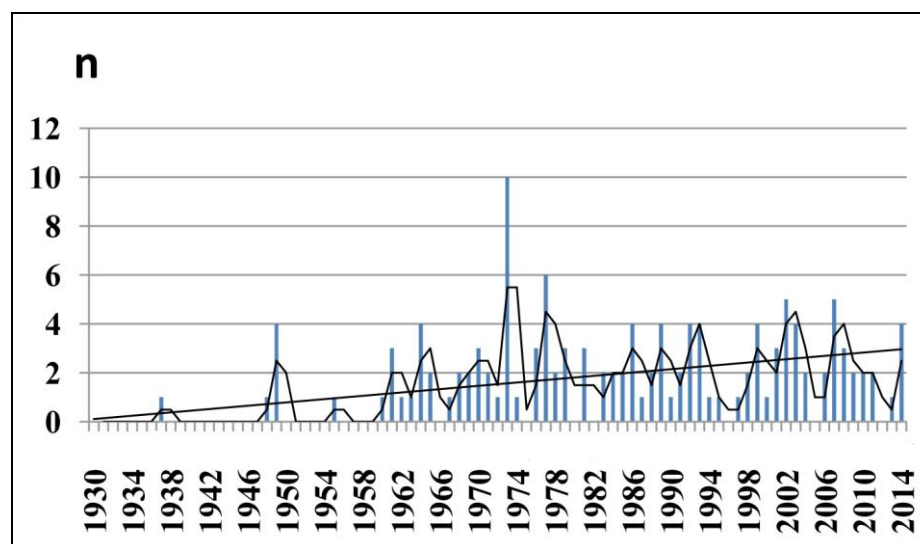


Fig. 4 Number of wind cases (n) of 25 m/s and more in the region of Nikitsky Botanical Gardens

Different phenomena have their own tendency, but in recent 15 years a positive tendency prevails due to global warming. According to this trend total number of phenomena increases. The biggest number was marked in five-year periods: 2001-2005 and 2006-2007 (30, 32) NHP (fig.2); it can be caused either by intensive anomalous synoptic situations or more thorough registrations. There is a tendency to more frequent heavy rain and strong wind (Fig. 3-4). According to interannual dynamics of heavy rain phenomena (Fig.3), 11-years cycle of solar activity is traced in alternation of occurrence increasing and decreasing periods. Connection between rainfall and solar activity cycle was mentioned in works of some scientists [1, 5, 6]. But to prove this hypothesis and create a model for prognostication, more in-depth studies are necessary. Predictable regularity of solar activity cycles permits to forecast humidity and possible activation of unfavorable phenomena. Cycles of atmospheric precipitation have grave consequences: 1. Water supply in the Crimea, capacity of reservoir replenishment, social problems, economical losses; 2. Landslide activization or damping, underflooding, duststorms, erosion by water and etc. [1, 6].

These trends present status of NHP for 1930 – 2014, what is quite stable for this period. Within new data, tendency direction can change.

On South Coast of the Crimea the most widespread natural hydrometeorological phenomenon is heavy rain, which causes catastrophic showers, mud-and-stone flows, inundation, floods of agricultural territory, living and production areas, even results changes of landscape, particular in the Crimean Mountains.

Rains, ≥ 30 mm per 12 hours and less, occur quite frequently on South Coast of the Crimea and in the region of agrometeorological station, about once or twice a year. Total number of NHP with liquid precipitations (heavy rain, shower), occurred on the territory of Nikitsky Botanical Gardens for 1930-2014, is 142. In recent 30 years frequency of rain (with such a level of precipitation) has considerably increased. (table 2).

Table 2.

Frequency of heavy rain (number) with different precipitation level, occurred in the region of Nikitsky Botanical Gardens for 1930-2014.

Years	Amount of precipitation, mm						
	≥ 30	≥ 50	≥ 100	≥ 150	≥ 200	≥ 250	≥ 285
1930-1940	20	4	2	1			
1941-1950	9	2					
1951-1960	15	2					
1961-1970	16	6	2	2	2	1	1
1971-1980	15	2					
1981-1990	21	3					
1991-2000	19	3					
2001-2010	23	2					
2011-2014	3	1					
1930-2014	142	26	4	3	2	1	1
Notes: Hereinafter: Empty table cells are for no occurrence.							

Peculiarities of atmospheric circulation, the Crimean Mountains and the Black Sea effect on seasonal distribution and type of precipitation on South Coast of the Crimea. Amount of precipitation in cold season is more than in warm, due to Mediterranean cyclones reached the Black Sea. Precipitations are more prolonged but not so intensive. In frost-free season the Crimean Mountains favor intensive orderly upward movement of air and convection [3]. Above mountains there are favorable conditions for activation of weather fronts, accompanied by intensive showers and thunderstorms, squalls, sometimes mud-and-stone flows, causing huge damage in agriculture. Annual variation of heavy rain frequency presents a seasonal periodicity. Out of 142 cases, registered in Nikitsky Botanical Gardens, heavy rains mainly occurred in summer (44) and autumn (54) months in recent 85 years. Such a seasonal periodicity was usually traced in decade periods (Fig.5). In winter month rain occurrence, ≤ 30 mm per 12 hours or less, is marked for 4 years per 10; spring period: 1-2 years per 10; summer time: 5-6 years/10; in autumn – 6-7 years/10 (table 3).

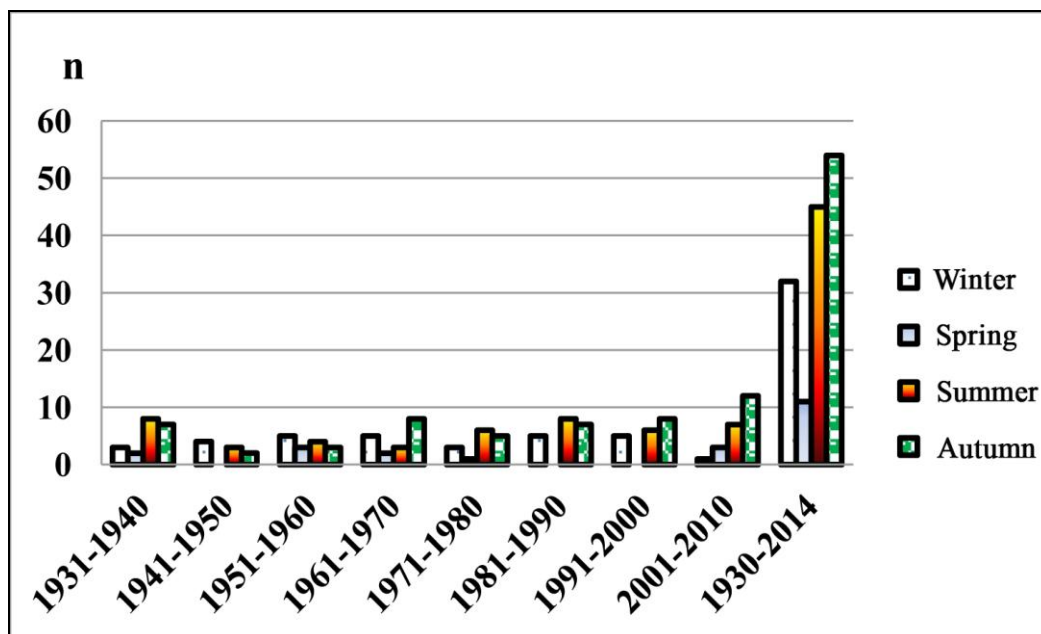


Fig.5 Heavy rain (number, n), ≥ 30 mm per 12 hours and less in the region of Nikitsky Botanical Gardens

Season	Amount of precipitation, mm						
	≥ 30	≥ 50	≥ 100	≥ 150	≥ 200	≥ 250	≥ 285
Winter (XII-II)	34	7	0	0	0	0	0
Probability, %	40	8	0	0	0	0	0
Spring (III-V)	12	0	0	0	0	0	0
Probability, %	14	0	0	0	0	0	0
Summer (VI-XIII)	44	11	2	1	0	0	0
Probability, %	52	13	2	1	0	0	0
Autumn (IX-XI)	54	8	2	2	2	1	1
Probability, %	64	9	2	2	2	1	1

In recent 85 years 26 cases of rain, ≥ 50 mm, were registered. Probability of such phenomenon on Nikitsky Botanical Garden area makes 3 years per 10. Heavy rains, ≥ 100 mm, were fixed here only 4 times (On August the 11th and 12th in 1939, on September the 5-6th in 1968). Rainfall of ≥ 150 mm has occurred 3 times (1939, 1968), 285 mm within one rain has been recorded only once. For the whole term of meteorological observations at agrometeorological station, the heaviest rain, in fact heavy shower occurred in September of 1968. It began raining at 14.30 on 4th of September and finished on 6th of September at 23.50 (in meteorology in pointed years conventional 1 day lasted since 21:00 till 21:00). That rain consisted of several heavy showers; then for 1 hour or less amount of precipitation reached 85,6 mm: since 21:42 till 22:42 it was 40 mm. In period from 04:30 on the 5th of September rain let up and till 10:10 30mm were added, since 13:40 till 14:30 – 37mm. At 17:45 rain let up. Total amount of precipitation in period since 12:30 on the 4th of September till 17:45 on the 5th of September made 270 mm. Since 17:45 till 19:20 it was raining slightly with breaks. At 19:20 on the 5th of September heavy rain began, lasting till 23:50 on the 6th of September (MSK), more 14,8 mm fell. In total for 3 days (the 4, 5 and 6th of September) amount of precipitation reached 284,8 mm. This rain was registered by hyetograph (rain grapher) of agrometeorological station “Nikitsky Garden”. Tape of hyetograph registered 24 discharges on the 5th of September. Till 2007 amount of precipitation fell on the 5th of September, 240 mm per day, was considered an absolute maximum not only for area of Nikitsky Botanical Gardens, for Ukraine in general. Heavy shower occurred on September the 4-6th in 1968 damaged vineyards largely: the soil was extremely rain-washed, deep gullies emerged, the

roads were silted by soil and stones, strong mud flows occurred there, human victims were registered. Within sovkhos (state farm) Gurzuf damage losses made 197500 roubles. Those days each hectare got 3000 m² of water, what effected on vine yield. Vine berries cracked, began to spoil. That`s why harvest began earlier than usually having low sugar concentration. Output of highly saccharine sorts of wine in the harvest of 1968 wasn`t large.

Shower or intensive rain of ≥ 30 mm per hour and less, occurred only 5 times for 1930-2009, 4 of them took place last decade (2001-2010). They are: heavy shower in September of 1968 mentioned above and rains occurred on the 14th of September in 2003, the 14th of July in 2004, the 26th of May in 2006 and the 10th of July in 2009. Amount of precipitation in 2003-2009 made 31-43 mm per one rain.

In spite of positive dynamics for good weather with gentle and moderate breezes, sometimes wind velocity reaches considerable values. Information about strong winds is of interest for different branches of national economy (construction and municipal engineering etc.). Especially these data gain importance for health-resort zone, gardening, park construction and etc.

As a rule the strongest and prolonged storm winds occur in cold season on South Coast of the Crimea. Taking into consideration separate storm cases maximum wind velocity reaches 40-45 m/s in the region of Aj-Petri mountain, 28-30 m/s in the region of Yalta city [2,3], 35-40 m/s in Nikita region (table 4). In Yalta wind velocity having northeast or western and southwest flows is lower than in the high seas [2].

Table 4

Occurrence (number, n), frequency and probability of storm winds with various directions by wind velocity of 25 m/s and more in the region of Nikitsky Gardens (1930-2014)

Period (year, season)	Parameter	Wind direction, rhumb								Total
		N	NE	E	SE	S	SW	W	NW	
Year	Number	6	17	1	0	0	19	14	75	132
	Frequency, %	4	13	1	0	0	14	11	57	100
	Probability, %	7	20	1	0	0	22	16	88	155
	Velocity value, m/s	28-39	25-40	25	0	0	25-40	25-34	25-40	25-40
	Probability 25-30 m/s	17	71	100	0	0	63	79	69	67
	Probability 35-40 m/s	1	1	0	0	0	1	0	11	9
Winter (XII-II)	Number	6	8	1	0	0	8	7	41	71
	Frequency, %	8	11	1	0	0	11	10	58	54
	Probability, %	7	9	1	0	0	9	8	48	84
Spring (III-V)	Number	0	6	0	0	0	2	4	15	27
	Frequency, %	0	22	0	0	0	7	15	56	20
	Probability, %	0	7	0	0	0	2	5	18	32
Summer (VI-XIII)	Number	0	0	0	0	0	0	1	0	1
	Frequency, %	0	0	0	0	0	0	100	0	1
	Probability, %	0	0	0	0	0	0	1	0	1
Autumn (IX-XI)	Number	0	3	0	0	0	9	2	19	33
	Frequency, %	0	9	0	0	0	27	6	58	25
	Probability, %	0	4	0	0	0	11	2	22	39

Wind of 25 m/s and more occurs due to strengthening continental anticyclone wedge spreading to southwest, and simultaneous deep cyclone from south or southwest to east of the Black Sea [3]. Frequency of storm winds isn`t similar in different regions of South Coast of the Crimea, but all over this phenomenon dominates in cold season. During November-March in Yalta 80% of all storm winds occur [2], Nikita – 82%. According to observation data for 1930-2014 maximum number of storm winds of 25 m/s and more was registered in the region of Nikitsky Botanical Gardens mainly occur in winter months (54%), minimum number is in summer months (table 4, fig.6). During summer period, storm wind of 25 m/s,

was recorded only once in recent 85 years. Seasonal periodicity keeps in decade periods (Fig.6).

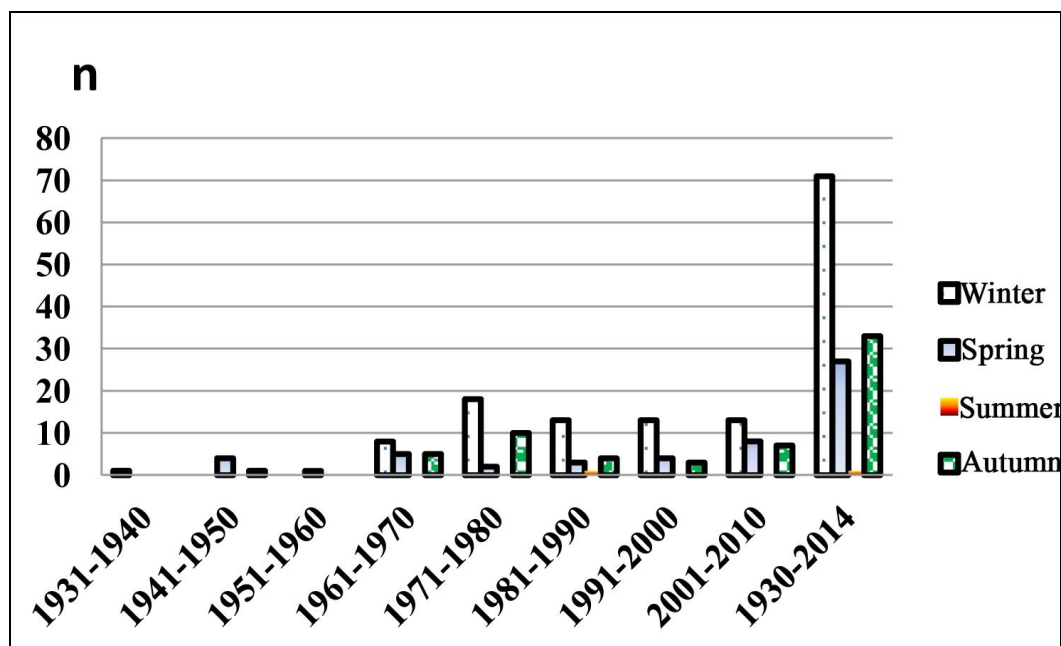


Fig.6 Number (n) of storm winds of 25 m/s and more occurred in the region of Nikitsky Botanical Gardens according to seasons

Within Yalta wind velocity of 25m/s or more is registered annually [2]. According to analysis of wind observations at agrometeorological station “Nikitsky Garden” for period 1930-2014 (table 4) winds of 25 m/s or more occurred in the area of agrometeorological station once or twice a year (132 cases for 85 years). The most frequent wind velocity is 25-30 m/s (up to 67% of total) (see table 4). Winds of ≥ 30 m/s were registered 49 times for these years, once in two years approximately. Winds of ≥ 30 m/s mainly occurred in Nikitsky Botanical Gardens during period 1961-1990 (table 5). Hurricane force winds of ≥ 35 m/s were registered 21 times in recent years, once or twice per 10 years. 9 cases of hurricane force winds of ≥ 40 m/s occurred for period 1930-2014, approximately ones in 10 years. The highest winds on South Coast of the Crimea within agrometeorological station “Nikitsky garden” have southwest (SW) and northwest (NW) directions. On South Coast of the Crimea on the 15th of November in 1992 strong hurricane was registered. It resembled well-known Balaklava storm which took place on the 14th of November in 1854, it covered the Black Sea and the Crimea during Sevastopol siege by English and French armies and navy. Storm wind on the 15th of November in 1992 started at 03:43 and reached 12 m/s, rushes – 20 m/s. At 06:09 southwest wind reached parameters of NHP (30 m/s). At 8:17 wind velocity decreased till 22 m/s, at 10:09 wind became stronger till 30-34 m/s. At 12:35 wind became weaker - 20 m/s. Atmospheric pressure during this hurricane fell much: from 982 hPa at 21:00 till 965 hPa (724 mm of mercury at 06:00). For 9 hours it became 17 hPa lower. From 00 till 06 – 12 hPa lower. Hurricane was accompanied by heavy rain, a number of precipitations made 36 mm. The losses caused by this hurricane were estimated at billions of roubles. In Yalta port some motorboats went down, many vessels, harbor cranes were damaged, quays and seaside were destroyed. In the sea wave height reached 10-12 m. In forest and parks trees were torn up by the roots, roofs were torn off many houses. As a rule strong winds on South Coast of the Crimea occur from November till March, but sometimes, for example in 1999 hurricane wind was registered on the 18th of May, when a lot of unripen fruits were brought down off

trees, grapes shoots were broken off, electricity cables were torn off. Near Arc at the entrance to Nikitsky Botanical Gardens billboards, set up on two metals were tied into a knot. In May of 2008 this phenomena occurred again.

Table 5

A number of incidents and probability of storm winds of 25 m/s and more within Nikitsky Botanical Gardens (1930-2014)

Years	Wind velocity, m/s			
	≥25	≥30	≥35	≥40
1930-1940	1	1		
1941-1950	5	2	1	1
1951-1960	2	1	1	1
1961-1970	18	10	3	3
1971-1980	30	13	3	3
1981-1990	21	9	3	
1991-2000	20	8	1	1
2001-2010	28	2		
2011-2014	7	3		
1930-2014	132	49	12	9
Probability, %	155	58	14	11
Notes Hereinafter : Empty table cells stand for absence of incident				

In the area of Nikitsky Botanical Gardens winds which become natural hydrometeorological phenomena have the following directions: north (N), northeast (NE), southwest (SW), west (W) and northwest (NW) (see table 4). In Nikitsky Botanical Gardens during the whole year, except summer period, when storm winds of NHP category are not registered (only 1 incident for 85 years), northwest winds prevail – 56-58% (fig.7) and probability these wind velocity reaches 40 m/s is the highest – 11%. Percentage of other wind directions in order of decreasing makes: SW – 14%, NE – 13%, W – 11%, N – 4% and E – 1% (Fig.7a).

In winter (December-February) northwest winds prevail. Frequency of other winds is not high and almost similar – 8-11% (fig. 7b). In case of Arctic air invasion northeast winds are accompanied by serious fall of temperature. Storm winds of 25 m/s and more are often phenomena within Nikitsky Botanical Gardens in winter period: 8-9 years per 10.

In spring period frequency of northeast winds increases up to 22% (Fig.7c). They are caused by northeast invasions and cold mountain air; in April-May – steppe hot dry winds occur which wither topsoil. In case of cyclone movement from west or northwest on the territory of the Crimea, west (15%) and southwest (7%) winds become natural hydrometeorological phenomena.

In autumn cyclone activity is registered, caused by southwest cyclones in the West of the Black Sea or in direction of Carpathians. As a result frequency of southwest (27%) winds increases considerably (Fig.7d). Frequency of other winds is not so high: northeast – 9%, west – 6%.

In spring and autumn probability of the wind to reach 25 m/s and more is less 2-3 times, than in winter – 3-4 years per 10 (see table 4).

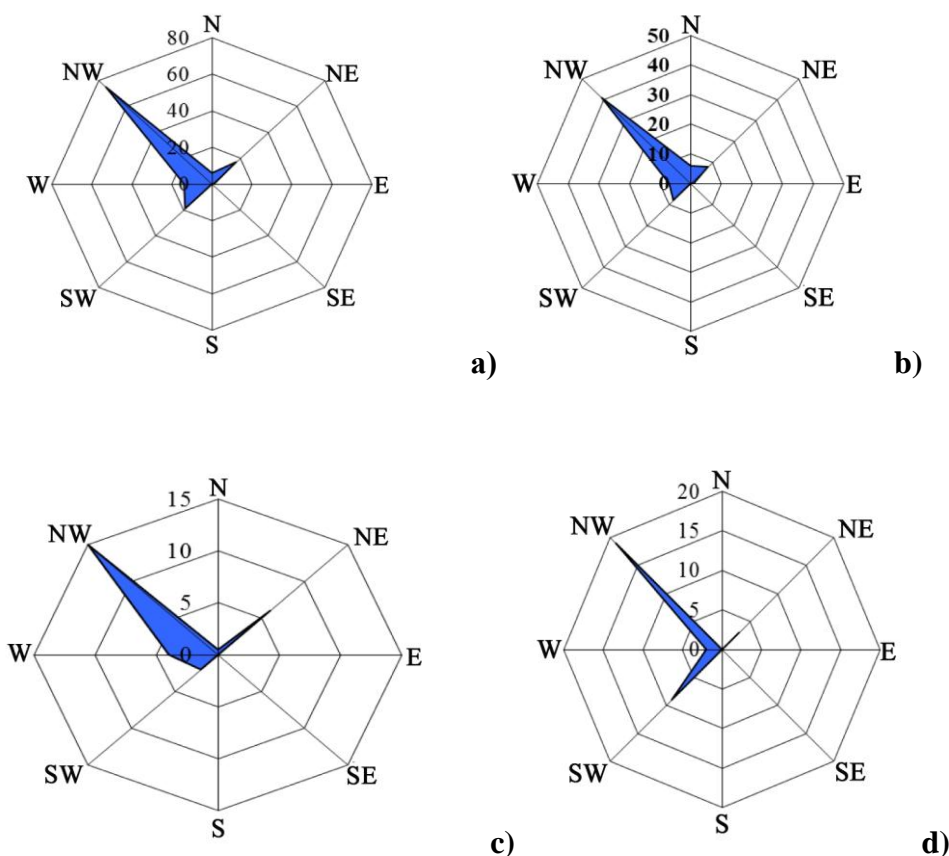


Рис. 7 Annual (a) and seasonal (b-d) roses of storm winds of 25 m/s and more within Nikitsky Botanical Gardens (observations for 1930-2014)
 a) I - XII; b) XII – II; c) III – V; d) IX - XI

On South Coast of the Crimea local storms, caused by downdraft from the passes in direction of the sea are rare phenomena. They occur as a result of winter continental monsoon activation. Almost all over storms start like bora, as a strong gusty katabatic current of dry and cold air, which was accumulated on mountain pastures as a result of advection of cold night radiative cooling [3]. Air currents, sliding the mountains and canyons, dropping from the passes, reach considerable velocity and become winds of different directions in certain regions of South Coast of the Crimea, they varies from west to northwest.

Strong bora on the territory of Yalta occurs quite often, approximately once per 4-5 years. But this phenomena isn't registered either agrometeorological station "Nikitsky Garden" (because of a sudden lowering of mountain level in village Nikita) or maritime hydrometeostation "Yalta" (because of limited observation). During bora wind velocity over mountains reaches 40 m/s (Cape Aj-Todor, canyon of three mountains (Vasiljevka)). Bora continues not so long, less than a day mainly. During bora winds have considerable vertical component, down directed. Bora causes some kind of cloudiness over mountains, spread along the mountains it resembles squall cloud [3].

November-March is a period when frequency of bora phenomena is the highest. During bora sharp variations of meteorological elements are registered: pressure, air temperature and etc. Particularly it concerns air temperature and humidity, their parameters decrease. As a rule wind is gusty.

In winter period atmospheric circulation over Crimean peninsula and the Black Sea is determined by Asian anticyclone. Arctic air invasions from Greenland over Scandinavia or from Taymyr island effected by cyclones which move from West of Europe, are accompanied by wind strengthening, air temperature on SCC is possible to decrease till $-12\dots-17^{\circ}\text{C}$ (1954)

[3]. Frost phenomenon -10°C and below, causing subfreezing and even destruction of warm-requiring ornamental plants and subtropical cultivars in parks and agricultural areas of South Coast of the Crimea, is registered in the region of agrometeorological station “Nikitsky Garden” (altitude above the sea level 208 m) 35 times in recent 85 years (table 6), on average 4 years per 10. Probability of temperature $\leq -11^{\circ}\text{C}$ is not so high – once or twice per 10 years. More often such low temperature is short-term at dawn, but in some years it kept 3-4 days running. So, in 1950 on 11-14th of January minimal air temperature was $-10\dots-12^{\circ}\text{C}$. In 1985 such low temperatures were keeping since 19 till 21 of February. Decreasing of minimal air temperature on South Coast of the Crimea till -13°C and below is a rare phenomenon, during period 1930-2014 it was registered only 6 times. Absolute minimum of air temperature for the period mentioned above was $-14,6^{\circ}\text{C}$ on the 11th of February in 1930. On the 8th of February in 1976 minimal air temperature decreased till $-14,5^{\circ}\text{C}$.

Heavy snow of ≥ 20 mm per 12 hours and less was registered in the region of Nikitsky Gardens 7 times for 1930-2014 (see table 6). Particular amount of precipitation fell in 1961 on the 24th of December – 31,1 mm, and on the 31st of January - the 1st of February in 1988 it made 27 mm. In March of 2003 snowfall of 26 mm was recorded. Taking into consideration all years of meteorological observations in the region of Nikitsky Botanical gardens maximum height of the snow cover reached 56 sm (the third decade of February in 1985). In the end of January 1963 and beginning of March 1987 height of snow cover made 48 sm, the end of January in 1996 and 2012 – 41 sm and 33 sm. Within Nikitsky Botanical Gardens under weight of snow in 2012 large branches of trees snapped, some trees fell. Snow cover caused by snowfall complicates traffic on South Coast of the Crimea. On some road sections characterized by big slope angle traffic is stopped due to snow reel and ice-covered ground. Icy condition of roads, causing considerable troubles for traffic on South Coast of the Crimea, occurs in winter period annually (January-February) not only after snowfall of 20 mm, even of 5-7 mm but accompanied by air temperatures below zero. Probability of heavy rain is once per 10 years.

Table 6

Number (1930-2014) and probability of NHP occurrence within Nikitsky Botanical Gardens

Natural hydrometeorological phenomena	Number	Probability of occurrence (number per years)
Frost $\leq -10^{\circ}\text{C}$	35	Once per 4 years
Heavy snow ≥ 20 mm per ≤ 12 h	7	Once per 10 years
Hail ≥ 20 mm	4	Once per 20 years
Fog < 100 m for ≥ 12 h	2	Once per 40 years
Hot dry wind	4	Once per 20 years
Tornado	1	Once per 85 years
Hard frost	1	Once per 85 years
Temperature drop	2	Once per 40 years

Conclusions

This work presents the most comprehensive description of natural hydrometeorological phenomena occurred in the region of Nikitsky Botanical Gardens during period of 1930-2014 according to data of agrometeorological station “Nikitsky Garden”. Phenomena dynamics, distribution during a year and probability of occurrence were considered as well.

Analysis of extreme weather phenomena changes which take place within Nikitsky Botanical Gardens area induces to believe that on South Coast of the Crimea they can strengthen and become more frequent against the background of global warming. During period of 1930-2014 in the region of Nikitsky Botanical Gardens 330 cases of NHP were

registered. The most frequent of them are heavy rain, strong wind and decrease of temperature till -10°C .

In-depth researches are necessary to confirming a hypothesis about correlation of changes in amount of precipitation, cycle of solar activity and development of forecasting model.

Rain of ≥ 30 mm per 12 hours and less are registered 1-2 times a year within Nikitsky Botanical Gardens area. A number of such cases has considerably increased in recent 25 years. In winter months they occur 4 years per 10, in spring period - 1-2 years per 10, in summer – 5- 6 years per 10, in autumn - 6-7 years per 10. Probability of rainfall of ≥ 50 mm in the region of Nikitsky Botanical Gardens makes 3 years per 10. The most dangerous is rainfall of 100 mm and more (once per 30 years), which causes marked material damages in different sectors; rainfall of more than 150 mm occurs once per 40 years, more than 250 mm – once per 85 years. Heavy shower is registered once per 20 years on average.

Winds of 25m/s and more occur 1-2 per year, ≥ 30 m/s – once per 2 years. Mainly wind velocity (NHP) reaches 25-30 m/s (67% of total). Probability of hurricane force wind of ≥ 35 m/s is 1-2 per 10 years. Wind directions capable to become natural hydrometeorological phenomena are north, northeast, east, southwest, west and northwest. The most devastating winds are southwest and northwest. During the whole year, except summer, when storm winds from NHP category don't usually occur (only once per 85 years), northwest winds prevail – 56-58% of total during the year, at the same time probability these winds reach hurricane velocity of 40 m/s is the highest, up to 11%. Percentage of other wind directions during the year ranges from 1 up to 14%.

In winter period northwest winds prevail. Frequency of other winds is not so high and approximately equal – 8-11%. Storm winds of 25 m/s and more occur quite often in winter within Nikitsky Botanical Gardens area: 8-9 years per 10. Spring period is characterized by often northeast winds – up to 22%, in autumn – southwest (up to 27%). In spring and autumn periods probability that wind velocity reaches 25 m/s and more is 2-3 times less than in winter and makes 3-4 years per 10.

Frost till -10°C and below, causing subfreezing and even destruction of warm-requiring ornamental plants and subtropical cultivars on the territory of parks and agricultural areas on South Coast of the Crimea in the region of agrometeorological station “Nikitsky garden” are registered 4 years per 10 on average. Probability that temperature decreases till $\leq -11^{\circ}\text{C}$ is not considerable: 1-2 years per 10. More often such frost phenomenon is short-term, but sometimes it keeps for 3-4 days running.

Probability of heavy snow of ≥ 20 mm per 12 h and less is once per 10 years, hail with hailstone of ≥ 20 mm across diameter and dry hot wind is once per 20 years, heavy prolonged fog and temperature drop occurred once per 40 years. Tornado and hard frost were registered only once per 85 years.

These data about natural hydrometeorological phenomena are of interest for different branches of national economy (building, municipal engineering and etc.). They are particularly important for development of recreational field, gardening and landscaping.

Received information should be taken into consideration while planning economic advancement, working out directions on adequate valuation of hazards and managing them, development of protective steps to prevent and reduce negative effect after them.

Results of this research are possible to apply as a reference material to investigate microclimate within Nikitsky Botanical Gardens area and Big Yalta.

Gratitudes

The author appreciates sincerely meteorologists of all generations of agrometeorological station “Nikitsky Garden”, who carried out meteorological observations

day and night in spite of shower, hot, freezing or windy weather. She thanks Fursa D.I., a head of agrometeorological station "Nikitsky Garden" (1959-2006) for collection, safety and systematization of archival material, colleagues-meteorologists Fursa V.P., Misyura N.V., Antonnikova L.A., Protsyk V.F., Reshetnichenko V.N., Maistrenko N.A., Korsakova P.B. for primary treatment of meteoelements.

References

1. *Bokov V.A.* Ekogeodinamika Krymskogo regiona: kontseptualniye podhodi // Geopolitika ekogeodinamika regionov. – 2003. – Vyp. 1. – S. 7-11.
2. *Zats V.I., Lukjanenko O.A., Yatsevich G.V.* Gydrotermichesky rezhym Yuzhnogo berega Kryma. – L.: Gydrometeoizdat, 1966. – 120 s.
3. *Klimat i opasniye gydrometeorologicheskiye yavleniya Kryma / Pod red. G.K. Loginova, M.B. Barabash.* – L: Gydrometeoizdat, 1982. – 318 s.
4. *Osadchy V.I., Babichenko V.N.* Dinamika stikhijnyh gydrometeorologicheskikh yavlenij v Ukraine // Ukr.geogr.journ. – 2012. - №4. – S. 8 – 14.
5. *Parubets O.V.* Analiz klimaticheskikh ryadov Krymskogo poluostrova // Ekosistema, ih optimizatsiya i ohrana. – 2009. – Vyp.20. – S. 154 – 164.
6. *Transformatsiya landshaftno-ekologicheskikh protsessov v Krymu v XX – nachale XXI veka / Pod red. d.g.n., prof. V.A. Bokova.* – Simferopol: DOLYA, 2010. – 304 s.
7. *IPCC, 2007: Summary for Policymakers/ In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change / S.Solomon, D.Qin, M.Manning* – Cambridge University Press, Cambridge, UK and New York, USA.

Korsakova S.P. The review of natural hydrometeorological phenomena within region of Nikitsky Botanical Gardens // Works of the State Nikit. Botan. Gard. – 2014. – V. 139 – P. 74 – 87.

The detailed analysis of space-time distribution of natural meteorological weather phenomena occurred in the region of Nikitsky Botanical Gardens over a period of 1930-2014 was carried out for the first time. Trends and patterns of the interannual meteorological hazards were identified. Natural hydrometeorological phenomena are the most dangerous result of the climatic instability. Due to considerable climate fluctuations in recent years, their number has increased and in most cases they become catastrophic. Analytical generalization of such phenomena probability is necessary to develop directions in an appropriate assessment of the possible risks and managing them.

Key words: *climate, global climatic changes, meteorological conditions, natural hydrometeorological phenomena, risk.*