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Weather and climate facts for year 2019 in Bulgaria

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Abstract: This is a review paper describing climate and weather facts for year 2019 in Bulgaria. They are based on meteorological data from the National Institute of Meteorology and Hydrology (NIMH), which is its national weather service, but also from other sources of data and information. The paper is an adapted text from the Annual hydro-meteorological bulletin of NIMH, published in March 2020. Target readers are the wider meteorological scientific community in Bulgaria and around the world. The measurements and analyses discussed here reveal that 2019 is the warmest in Bulgaria since 1930 and the annual precipitation amounts are around or below normal.

Keywords: Weather, climate, national annual meteorological bulletin.

1. INTRODUCTION

The National Institute of Meteorology and Hydrology (NIMH) – the national hydro-meteorological service of Bulgaria – issues a Monthly hydro-meteorological bulletin, ISSN 1314-894X. Its last edition for the previous month is available online at http://www.meteo.bg/meteo7/sites/storm.cfd.meteo.bg.meteo7/files/Bulletin.pdf. The text is in Bulgarian. In March 2020 NIMH issued an Annual hydro-meteorological bulletin for year 2019 containing analyses and data based on the monthly bulletins for the year as well as other sources of information. It can be found online at the official web-site of NIMH http://www.meteo.bg/ but will be replaced by a new yearly 2020 issue by March 2021. This paper presents an adapted version in English of the meteorological part of the annual bulletin for 2019. The aim is to reach out the international scientific meteorological community on the pages of this journal. The information presented is divided in section devoted to atmospheric circulation and annual summary of the most important meteorological elements such as temperature, precipitation, wind, sunshine, snow cover. Time-series of temperature and precipitation for the last decades are also

given. The most significant weather events for the year are listed and analyzed. The paper follows the model of similar documents of other meteorological services around the world like, for example, the UK MetOffice (Kenton et al. 2019) and the Meteorological agency of Japan and their Climate change monitoring report, 2018.

The data given in the paper are from the networks of stations of NIMH. The networks comply with the standards of the World Meteorological Organization (WMO). All data undergo daily quality control before being used for climate assessment. The reference climate period is 1961-1990 as with the WMO current recommendation. For some parameters however the reference period is more recent – 1981-2010 because there are no time-series long enough to cover the recommended period 1961-1990. Most of the parameters on the maps show deviation from the climate normals. Nevertheless, to give an idea of the characteristic values of the meteorological parameters, maps of their actual annual and seasonal averages are also shown. Maps of actual monthly averages can be found in the issues of the Monthly Hydrometeorological Bulletin of NIMH for 2019 (see reference). The categories below, around, and above normal are often used and they are defined against the climate normal for the WMO recommended period 1961-1990 unless stated otherwise. Rounded numbers appear often but exact numbers have been used for the computations.

2. METEOROLOGICAL FACTS FOR YEAR 2019

Year 2019 was the warmest since 1930. The mean annual temperature in average for the country is 12.5°C, which is 2°C above the climate normal for 1961-1990.

The mean annual country-mean maximum temperature is 18.8°C, which is 3°C above normal.

The highest measured maximum temperature was 39.4°C registered in Radnevo, region of Stara Zagora, on 3.VII.

The mean annual country-mean minimum temperature is 7.2°C, which is 1.8°C above normal.

The lowest measured minimum temperature is –24.4°C registered in the weather station on peak Mussala (2925 m) on 7 and 8.I. The lowest minimum temperature, measured in stations below altitude of 1500 m, is –21.5°C in Koprivshtitsa, region of Sofia, on 8.I.

The annual country-mean amount of precipitation is 573 mm that is 89% of normal. The biggest daily amount of precipitation was 197 mm from rain, registered in Dermantsi, region of Lovech, on 21.V.

The strongest wind speed in populated area was 40 m/s from northeast, measured in Sliven on 22.II.

The deepest snow cover in populated area was 110 cm in Manastir (1500 m above sea level), region of Smolyan, registered on 16.II. The deepest snow in stations on mountain tops was measured at Rozhen (1750 m), region of Smolyan, on 1.II – 189 cm.

The day with the biggest number of registered lightning flashes (49000) in the country was 24.VI. It was also the day with the highest number of flashes ever measured in Bulgaria since 2012. These statistics are based on data from ATDNet.

3. ATMOSPHERIC CIRCULATION

Figure 1 shows the mean seasonal height at geopotential surface of 500 hPa as deviation from normal for all seasons of 2019. The reference period is 1981-2010. Maps are based on the atmospheric reanalysis of Kalnay *et al.* (1996) and are produced on the website of NOAA-ESRL Physical Sciences Division, Boulder, Colorado, http://www.esrl.noaa.gov/psd/.

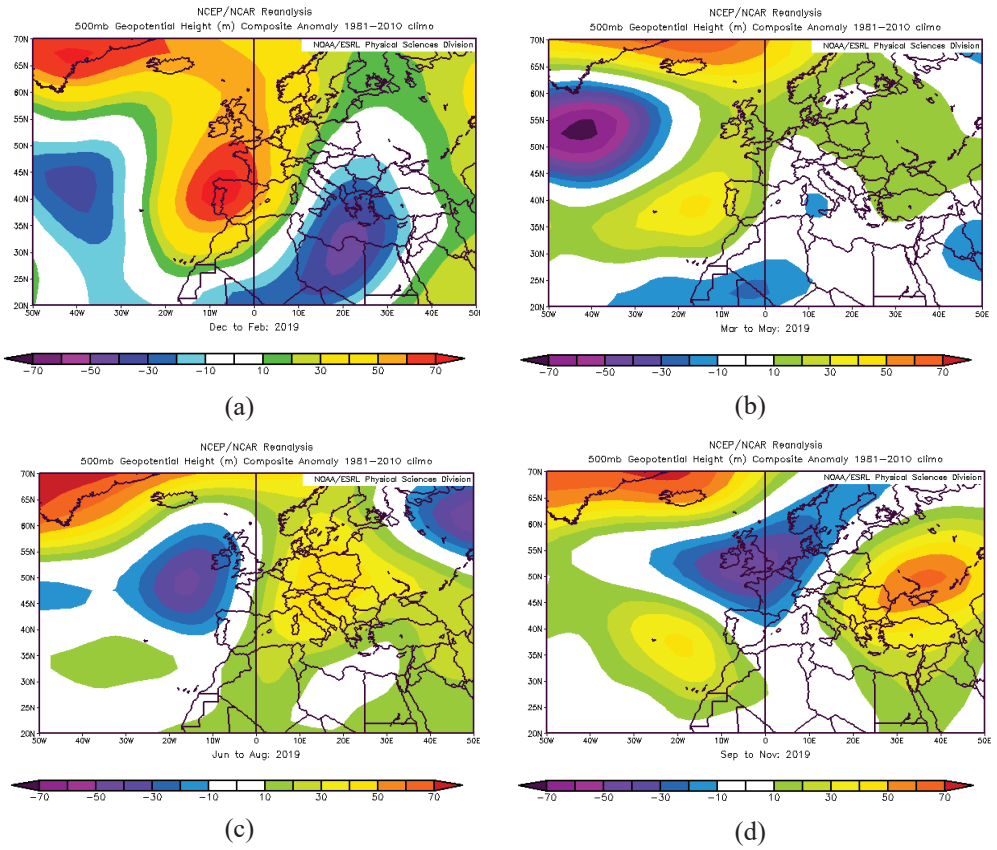


Fig. 1. Deviation of the mean seasonal height (m) of geopotential surface at 500 hPa relative to the seasonal average for 1981-2010 for the four seasons of 2019: (a) – winter; (b) – spring; (c) – summer, and (d) – autumn.

Figure 2 shows the mean seasonal surface pressure as deviation from normal (reference period 1981-2010). The maps are based on the atmospheric reanalysis of Kalnay *et al.* (1996). This gives a general idea of the atmospheric circulation for each season.

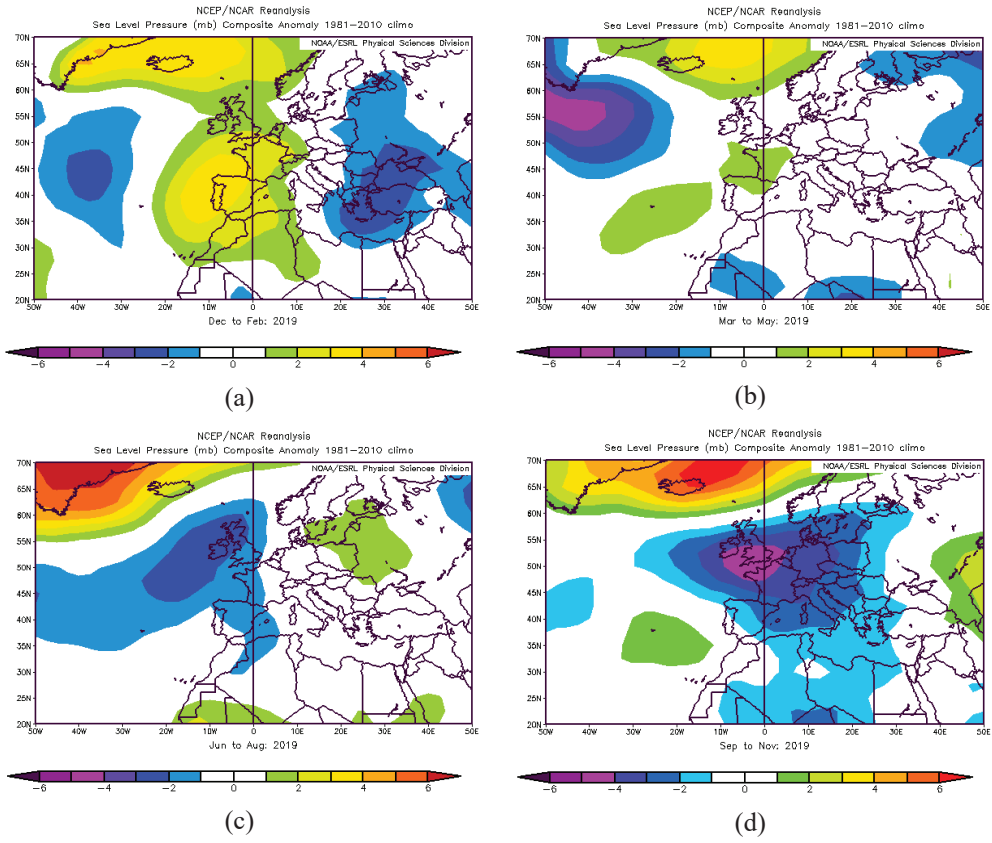


Fig. 2. Deviation of the mean seasonal surface pressure (mb) from the normal for 1981-2010: (a) – winter; (b) – spring; (c) – summer; (d) – autumn.

In the winter[1] of 2019, Bulgaria was under the influence of a zone with cyclonic activity in the Eastern Mediterranean (Fig. 1a) and the mean seasonal surface pressure was lower than normal (Fig. 2a). There was no apparent dominant circulation pattern in the region of the country in spring[2] (Fig. 1b) and the mean seasonal surface pressure was close to normal (Fig. 2b). There was an anticyclonic anomaly in Central Europe in summer[3] influencing Bulgaria (Fig. 1c) but the mean seasonal surface pressure was

[1] Winter 2019 is the three-month period December 2018 – January 2019 – February 2019. December 2019 will be counted for winter 2020.

[2] Spring is the three-month period March-April-May.

[3] Summer is the three-month period June-July-August.

close to normal (Fig. 2c). In autumn[4] the country was on the western periphery of an area of anticyclonic circulation (Fig. 1d) but the mean seasonal surface pressure was relatively low (Fig. 2d).

4. TEMPERATURE

4.1. General analysis of temperature

Figure 3 shows maps of the mean annual temperature for year 2019 and its deviation from the normal. The mean annual country-mean temperature[5] is 12.5°E.

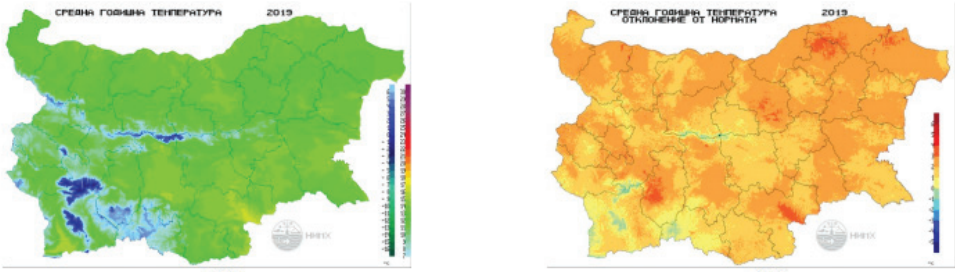


Fig. 3. (a) Mean annual temperature (°C) for 2019 and (b) its deviation from normal

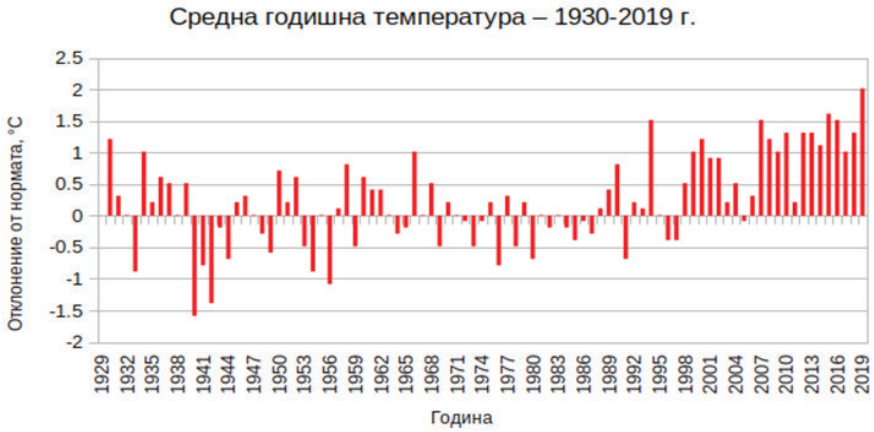


Fig. 4. Mean annual country-mean temperature for 1930-2019 as deviation from normal.

[4] Autumn is the three-month period September-October-November.

[5] The mean annual country-mean temperature is based on data from all stations of NIMH with continuous time-series for the period 1930-2019.

Figure 4 shows the time-series of the annual mean temperature for the period 1930-2019 for the whole country as deviation from normal. The mean annual temperature for 2019 is 2°C above normal. It is seen that year 2019 is the warmest one since 1930.

Figure 5 shows maps of the mean seasonal temperature and its deviation from normal for the four seasons. Figure 6 shows maps of the deviation from normal of the mean monthly temperature for all 12 months of 2019.

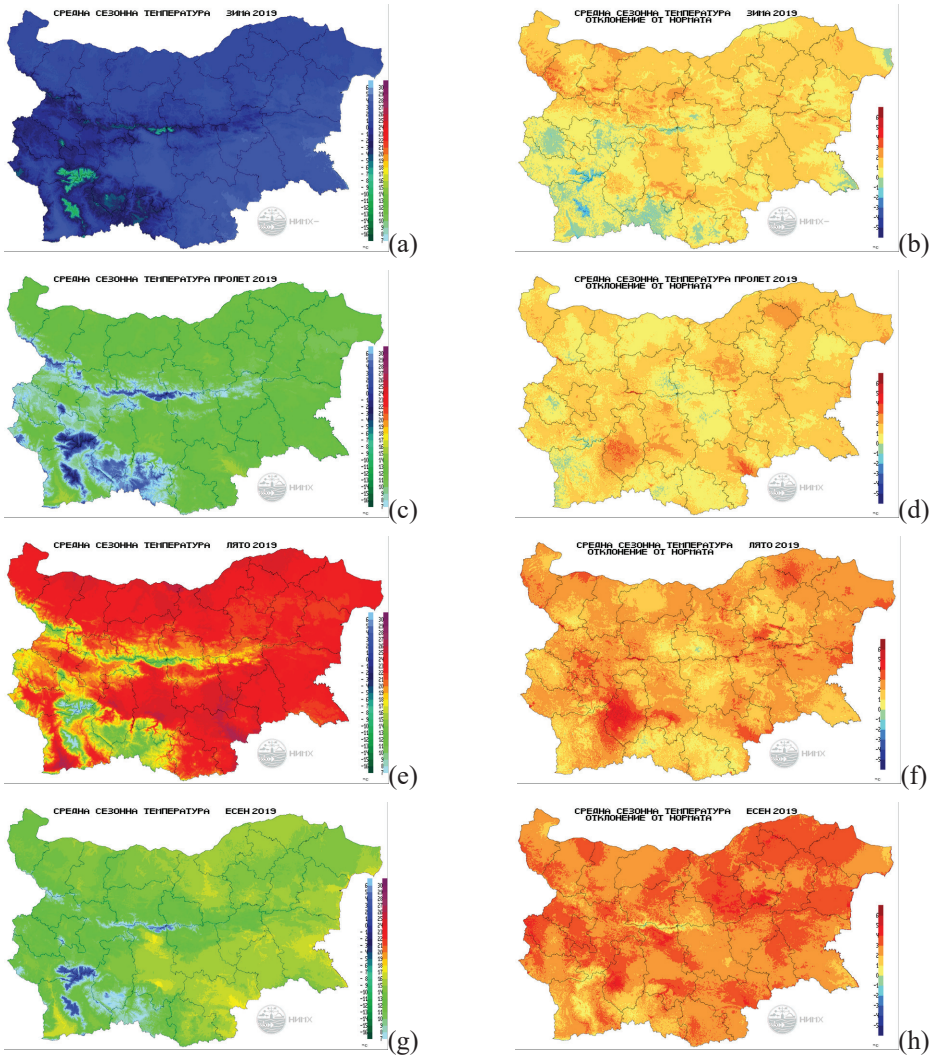


Fig. 5. Mean seasonal temperature (°C) (left) and its deviation from normal (°C) (right) for the four seasons of 2019: (1st row) – winter; (2nd row) – spring; (3rd row) – summer; and (4th row) – autumn.

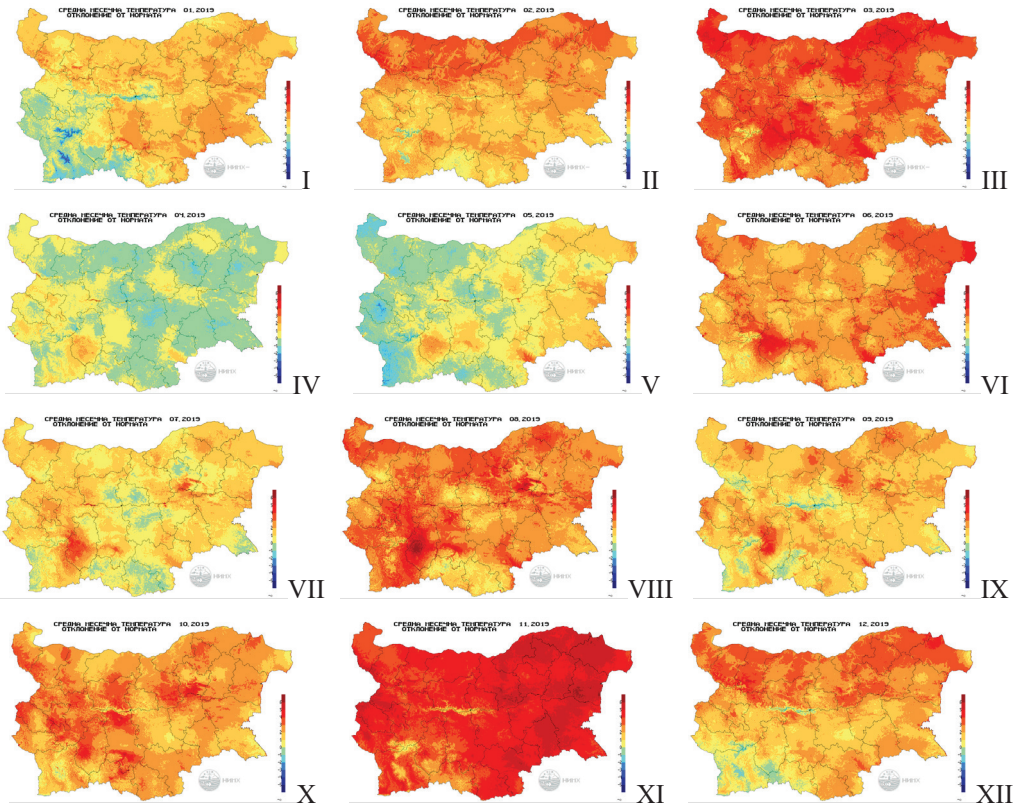


Fig. 6. Mean monthly temperature (°C) as deviation from the norm (°C) for year 2019

Autumn is the warmest season relative to the norm. It can be seen on Figure 5. The autumn of 2019 is one the five warmest since 1950. Summer is warmer than normal too but there have been hotter summers in the recent years. Winter and spring are with mean seasonal temperature near and above normal.

The mean annual country-mean maximum temperature is 18.8°C, which is 3°C above normal. The annual mean country-mean minimum temperature is 7.2°C, i.e. 1.8°C above normal. The annual highest maximum temperature is 39.4°C and was registered in Radnevo, region of Stara Zagora, on 3.VII. The annual lowest minimum temperature (–21.5°C), in stations below 1500 m of altitude, was measured in Koprivshtitsa, region of Sofia, on 8.I. However, the lowest of all measured minimum temperatures (–24.4°C) was registered on peak Mussala on 7 and 8.I.

The month of November is the warmest relative to the norm (see Figure 6). The deviation from normal of the mean monthly temperature in stations is between 3 and 6°C above normal. The second warmest is the month of March where the mean monthly temperatures are between 2 and 4.5°C above normal. The third warmest is the month of August with mean monthly temperatures between 0 and 4.7°C above normal. The

months of April, May, and July are those with temperatures near normal in average for the country. For example in May their deviation from normal is between –1.5 and +2.5°C.

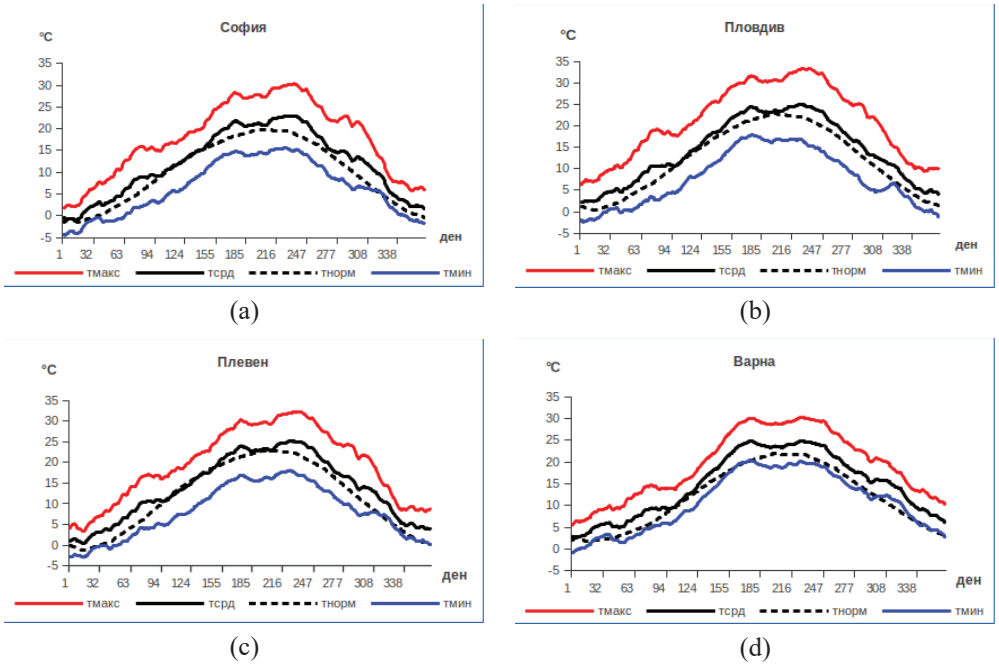


Fig. 7. Annual temperature trend (°C) as 30-day running average for major cities – Sofia (a); Plovdiv (b); Pleven (c); Varna (d). /Red line – T_{max}, blue line – T_{min}, black solid line – T_{mean}, black dotted line – T_{normal}/

Figure 7 shows the annual cycle of the 30-day running average of the minimum, maximum, and daily mean temperature and its climate norm for the stations in Sofia, Plovdiv, Pleven, and Varna. One can see that the mean daily temperatures are mostly above normal through the year except around the months of April and May when they are rather near normal. It is also interesting that the minimum temperature 30-day averages tend to be near the monthly-mean-temperature climate norm.

4.2. Number of hot and freezing days

By definition a hot day in Bulgaria is a day with maximum temperature above 32°C. The number of hot days in Bulgaria has increased in the last decades. It can be diagnosed in Figure 8. The diagrams show the deviation of the number of hot days from the average for the baseline period 1961-1990 separately for North and South Bulgaria.

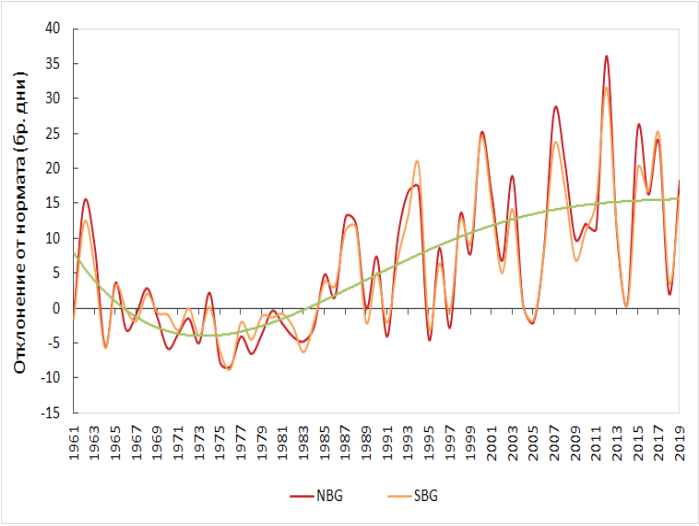


Fig. 8. Multiannual change in the average number of hot days in the period 1961-2019 compared to the reference period 1961-1990 in North Bulgaria (NBG) and South Bulgaria (SBG).

Those deviations in the 1980s vary from 8.8 to 15.3 days. In the most recent decades the upper limit has increased more than two times up to 36.1 days. The rate of the trend however has slowed down. A statistically significant trend of increase of the number of hot days of 3.5-3.6 per decade is found in the data from more than 90% of all climate stations. Year 2012 was the year with the highest country-mean number of hot days – 43. The stations with the highest ever number of hot days in North and South Bulgaria are Brashlen (73 days) and Sandanski (96 days), respectively. The maximum numbers of hot days in 2019, for North and South Bulgaria, are 72 (in Dalgopol) and 80 (in Parvomay), respectively.

By definition for Bulgaria a freezing day is a day when the maximum temperature does not exceed 0°C. The number of freezing days is one of the main indicators for the severity of winter. There is a pronounced tendency for decreasing of the number of freezing days in the last two decades (Fig. 9). The deviations from normal vary from –8.2 to 20.4 days until the middle of the 1980s. In the last 30 years the lower limit increased more than two times up to 15.6 days below normal. A statistically significant trend of decrease of the number of freezing days of 2.1-2.3 per decade is found in data from 44% of the stations in North Bulgaria and 18% of the stations in South Bulgaria. The year 1963 was with the highest country-mean number of freezing days – 32. The stations with the highest number of freezing days in North and South Bulgaria are Gramada (69 days in 1969) and Dragoman (49 days in 1962), respectively. The maximum number of freezing days for North and South Bulgaria in 2019 are 23 (in Omurtag) and 14 (in Bansko), respectively.

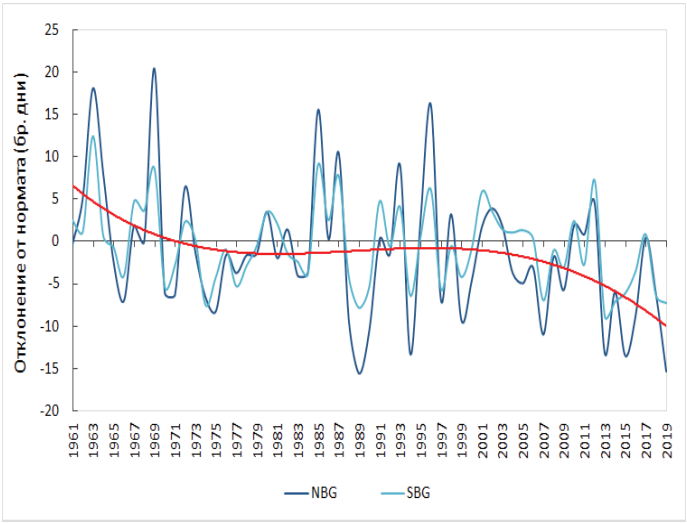


Fig. 9. Trend of the mean number of icy days for 1961-2019 compared to the reference period 1961-1990 in North Bulgaria (NBG) and South Bulgaria (SBG).

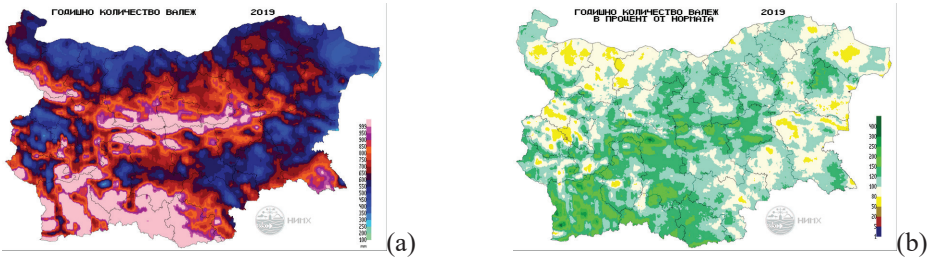
5. PRECIPITATION

Figure 10 presents maps of the annual amount of precipitations for 2019 as an absolute value and as a percentage of the climatic norm. Figure 11 shows the seasonal amount of precipitation in absolute values and in percent of the norm for the four seasons. Figure 12 presents the monthly amount of precipitations as a percentage of the climatic norm for the twelve months of 2019.

The country-mean annual amount of precipitation[6] is 573 mm. Figure 14 shows time-series of the annual amount of precipitation for the period 1930-2019 compared to the climate norm (horizontal line). The annual amount of precipitation for year 2019 is 89% of the norm.

The summer is the wettest of all calendar seasons of year 2019 (Fig. 11). The seasonal amount of precipitations is near or above normal in most stations of NIMH. One could say that winter, spring, and autumn are similar to each other in terms of precipitation. In general, the seasonal amount of precipitation in most NIMH stations is around and below the norm, but there is also a relatively small part of the country where there are stations with seasonal precipitation above normal.

[6] The country-mean annual amount of precipitation is based on data from all stations of NIMH with uninterrupted time-series for the period 1930-2019.

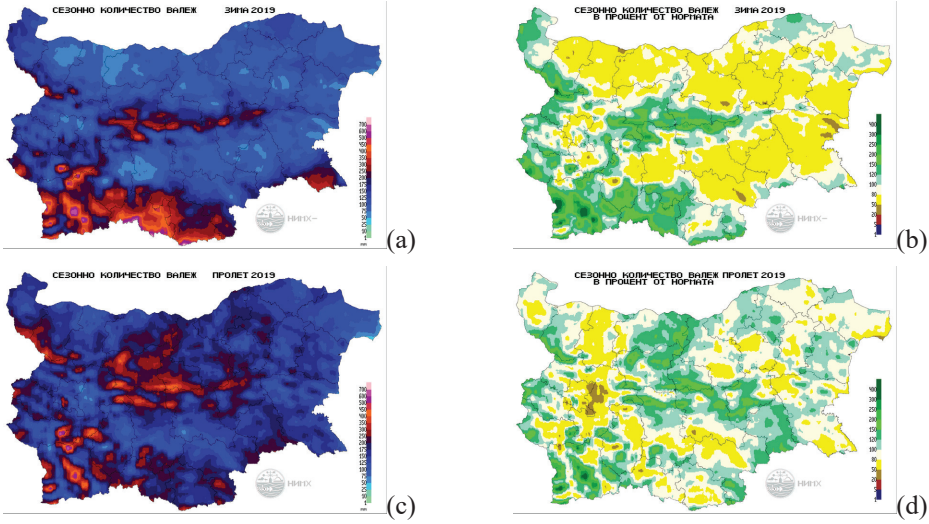


(a) (b)

Fig. 10. Annual amount of precipitation (mm) (left) and as a percentage of the norm (right).

The month of June is the wettest one. The monthly amount of precipitation is between 70 and 364% of the monthly norm in the stations of NIMH (Fig. 12). Next are the month of July, with monthly amount of precipitation between 45 and 276% of the norm, and the month of November, with monthly amount of precipitation between 45 and 200% of the norm. March is the driest, with monthly amount of precipitation between 1 and 79% of normal. The months of February, August, September, October, and December are similar in terms of precipitation and the monthly amounts of precipitation, in most of the stations of NIMH, are near or below the norm – between 1-10% and 116-142% of the norm.

The biggest amount of precipitation was measured in Dermantsi, region of Lovech, on 21.V – 197 mm from rain. It is also the largest 24-hour amount of rain in Spring. The biggest winter amount of precipitation was measured in Malko Turnovo, region of Burgas, on 11.I – 131 mm from rain. The biggest summer amount of precipitation was measured in Dalboki, region of Stara Zagora, on 3.VI – 111 mm from rain. The biggest autumn amount of precipitation was measured in Zlatograd, region of Kardzhali, on 21.XI – 95 mm from rain.



(a) (b)

(c) (d)

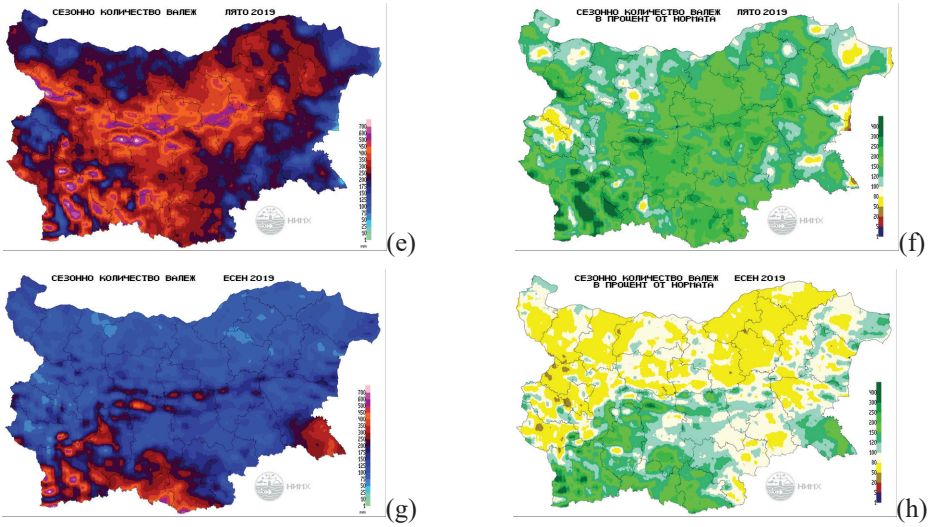
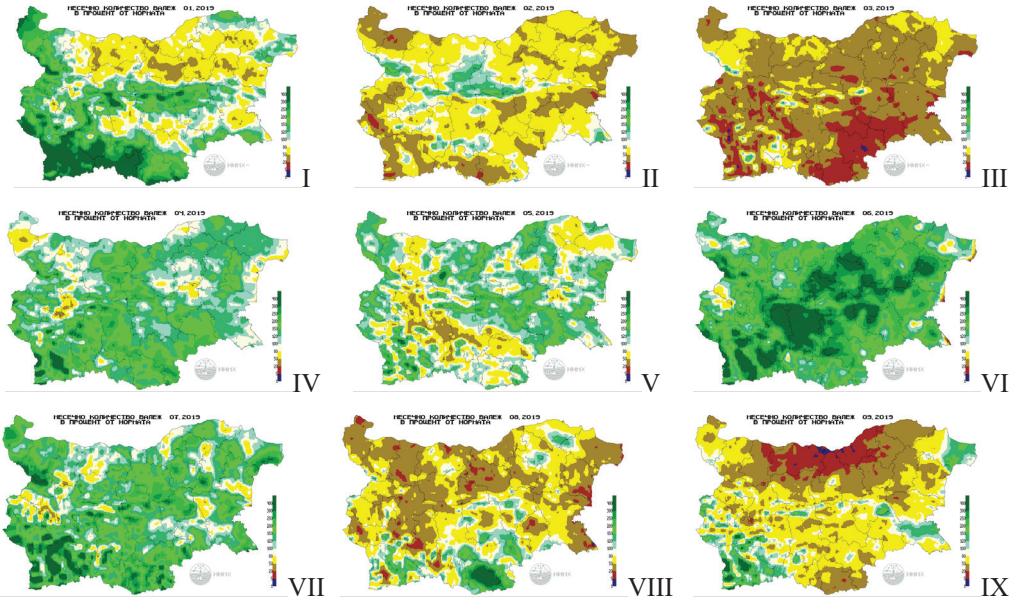


Fig. 11. Seasonal amount of precipitation (mm) (left) and in percent of the norm (right) for the four seasons of 2019; (1st row) – winter; (2nd row) – spring; (3rd row) – summer; (4th row) – autumn.



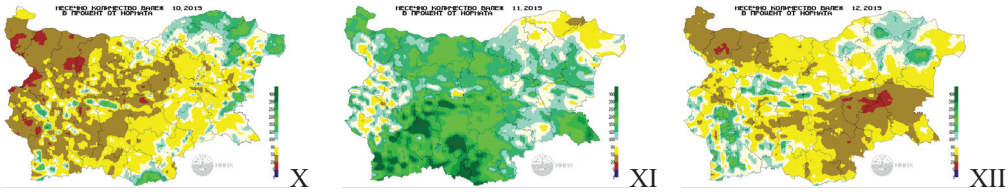
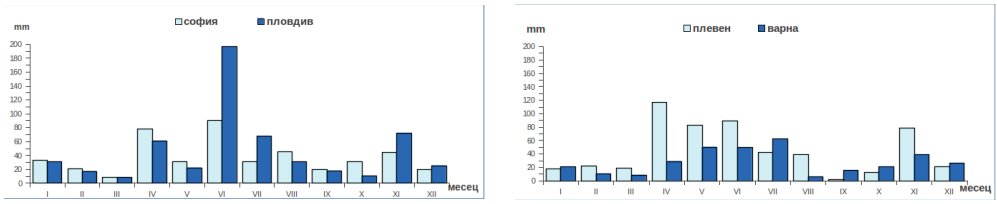


Fig. 12. Monthly amount of precipitation as a percentage of the norm for all months of 2019.

Figure 13 shows diagrams of the monthly amounts of precipitation for all months of year 2019 for Sofia, Plovdiv, Pleven, and Varna.



(a) (b)

Fig. 13. Monthly amount of precipitation for all months of 2019 for major cities: Sofia and Plovdiv (left); Pleven and Varna (right).

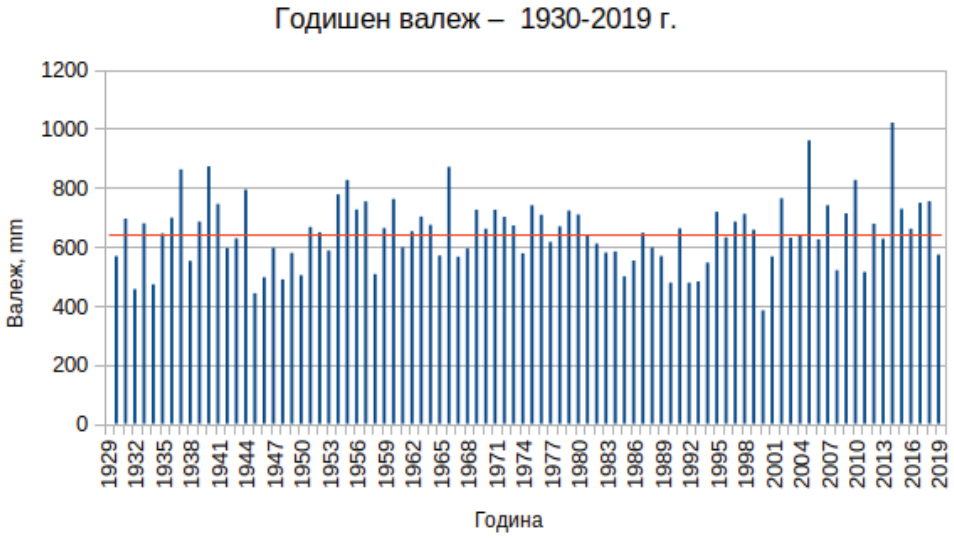


Fig. 14. Annual amount of precipitation for 1930-2019 compared to the climate norm (horizontal line).

6. STRONG WIND

Table 1 contains a list of the days with strong wind in 2019. A day with strong wind[7], for the purpose of this analysis, is defined as a day in which the number of operational stations of NIMH with strong wind is greater than 20.

Figure 15 shows maps of the sea-level pressure in the six days with the greatest number of stations with strong wind from Table 1. The following is a set of descriptions of the synoptic situations for these days:

The period 14-16.I is one of the six with strong winds. There is a cold front from northwest crossing the country. It is linked to a Mediterranean cyclone having its trajectory in South Greece (Fig. 15a). The winds are with different directions but mostly from west. The most exposed regions are North and East Bulgaria, the Upper Thracian plain and the Struma river valley. The values of the wind speed are often between 24 and 28 m/s.

There is a cyclone, centered to the north of the country, passing on 12.II. It is associated with a weather front (Fig. 15b). The maximum wind speed for the day is above 14 m/s in many stations across the country. The maximum values of the wind speed attained 24-31 m/s in some places in the Upper Thracian and the Danube plains.

Table 1. Strong wind data.

Month	Date	Number of stations with strong wind
I	14	24
I	15	45
I	16	27
II	12	45
II	22	49
II	23	29
III	5	27
III	10	27
III	16	29
IV	30	29
V	5	24
V	6	22
V	7	26
V	20	22
VI	25	22
VII	3	29
VIII	3	46
XI	4	34
XI	30	25
XII	22	37
XII	24	22
XII	30	27

[7] The wind is classified as “strong” if its maximum speed is equal or greater than 14 m/s.

During the days 22-23.II the country was in a front zone between a cyclonic vortex to the south and an anticyclone to the north (fig. 15c). The strong winds were found mostly in East Bulgaria, the Danube plain, and in the Struma river valley. The attained maximum values of the wind speed were mainly between 24 and 28 m/s but the station in Sliven reported 40 m/s. Sliven has a specific local topography facilitating strong northern downhill winds.

A cyclone and the associated weather front crossed the country on 3.VIII (Fig. 15d). The predominant direction of the wind was from northwest. The regions most affected by the strong winds, were the Danube plain, East Bulgaria, the Upper Thracian plain and the Struma river valley. The attained maximum values of the wind speed were 25-32 m/s.

On 4.XI Bulgaria was under the influence of southwest flow (Fig. 15e). The situation was favorable for foehn winds and that is why many stations, located in the northern mountain footsteps, reported strong southwesterly gusty winds reaching 17-21 m/s. Southern winds were also reported in East Bulgaria and in the Struma river valley.

The situation on 22.XII was similar to the one on 4.XI. Many stations in East Bulgaria and in the northern footsteps of the zonally unfolded mountain chains reported strong and gusty southerly winds (Fig. 15f). The attained maximum values of the wind speed were 20-26 m/s.

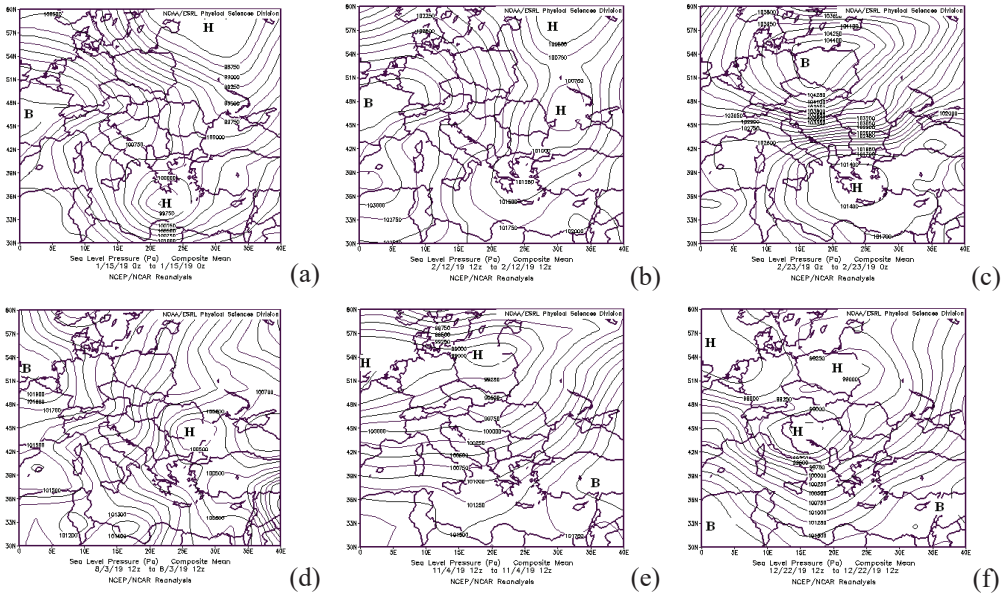
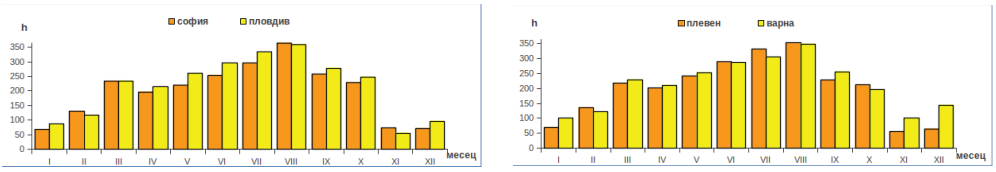


Fig. 15 Mean seas level pressure (Pa) on: (a) 15.I, 0 h Coordinated Universal Time (UTC); (b) 12.II, 12 h UTC; (c) 23.II, 0 h UTC; (d) 3.VIII, 12 h UTC; (e) 4.XI, 12 h UTC; (f) 22.XII, 12 h UTC.

7. CLOUDINESS AND SU NSHINE

The mean annual amount of cloudiness, evaluated in the stations of NIMH, is between 4 and 6.5 tenths, which is near normal. The annual number of clear-sky days, registered in the stations of NIMH, is between 25 and 140, which is around normal in a wide interval. The annual number of cloudy days is between 40 and 130, which is also around normal.

The annual sunshine duration, measured in the stations of NIMH, is between 1780 and 2730 h, which is near or below normal[8]. Figure 16 shows diagrams of the monthly duration of sunshine for all months of 2019 for Sofia, Plovdiv, Pleven, and Varna.



(a) (b)

Fig. 16. Monthly sunshine duration (hours) for all months of 2019 for major cities: Sofia and Plovdiv (left); Pleven and Varna (right).

8. SNOW COVER, BLACK ICE AND FROST

There are three periods with countrywide snowfall in 2019:

3-11.I: In the period from 3 to 8.I, there was a significant snowfall in North Bulgaria, in the region of Strandzha-Sakar in the southeast, in the mountainous region of Rila and the Rhodopes, and in the higher-ground fields of West Bulgaria. In the period 9-11.I there was snowfall in West Bulgaria and in the central parts of the country (Fig. 17a). In the Predbalkan[9], the Rhodopes, Strandzha and Northwestern Bulgaria on different days of the period the height of the snow cover reached between 20 and 50 cm

22-23.II: During the period, there was snowfall in most of the country except a part of East Bulgaria (Fig. 17b). The maximum snow depth reached 10-20 cm in stations in the Predbalkan and in the part of the mountain of Sredna gora near the town of Ihtiman.

3-4.XII: In that period the snowfall was mainly in Southwest and South central Bulgaria, in the region of Strandzha-Sakar, the Predbalkan, and in parts of Northeast Bulgaria (Fig. 17c). The maximum snow depth, between 10 and 30 cm, was measured in the central parts of the Predbalkan, in the region of Strandzha-Sakar, and in the mountainous region of Rila and the Rhodopes.

The biggest snow depth, in operational stations of NIMH, was measured in Manastir (1500m above sea level), region of Smolyan, on 16.II – 110 cm. In a station on a

[8] The climate norm for sunshine duration is based on data for the period 1981-2010.

[9] The semi-mountainous region to the north of the zonally unfolded mountain range of Stara planina (Balkan).

mountain top, the biggest snow depth was measured in the station of Rozhen (1750m above sea level) on 1.II – 189 cm.

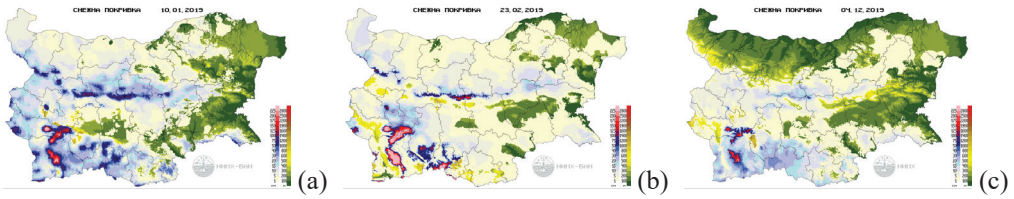


Fig. 17. Snow depth analysis for 10.I (a), 23.II (b), and 4.XII (c). Left color scale – snow depth in cm; right color scale – altitude in meters.

The following are the cases with observed freezing rain and black ice in 2019:

In the period of 10-11.I, there were stations reporting freezing rain or black ice in North central and Northeast Bulgaria. On 23.I, cases with black ice were reported in places in Northwest Bulgaria and in the West Rhodopes in the region of Blagoevgrad. On 16.II and 23.II, such cases were registered in places in East Bulgaria.

The frost is a meteorological phenomenon that occurs in the cold seasons but is considered critical only in the transitional months of September-October and April-May. In 2019, in these transitional months, there was a number of cases with frost conditions.

In April, the periods with frost in many places countrywide were: 1-5.IV, 16-17.IV, and 21-22.IV. In the month of May the most massively registered frosts were on 9.V when there were places with morning frost conditions mostly in the Upper Thracian plain and in high valley fields. In autumn, in September, the period with frost was 21-23.IX when the stations reporting frost were mostly in the valley fields in West Bulgaria and in the mountainous regions. In October, the periods with frosting were 7-17.X and 20-30.X., registered in stations in Northwest Bulgaria and in the high valley fields in the mountainous and semi-mountainous regions.

9. EXTREME-WEATHER DATA AND SIGNIFICANT WEATHER EVENTS

9.1. Extreme-weather data

Figure 18 shows the countrywide monthly mean number of days[10] with fog and thunder activity. It is based on the operational data from the synoptic stations of NIMH. The presence of thunder activity is subjectively determined by the observers in the stations. All cases with thunder activity in the vicinity or far from the station, or with observed only lightning without thunder, are taken into account. Figure 19 shows spatial distribution of the annual number of lightning flashes and the annual number of days

[10] For this purpose, a "day" is the 24-hour period between 7.30 h (8.30 h in summer time) on the previous calendar day to 7.30 h (8.30 h) on the calendar day with which the date is associated.

with flashes. They are based on data from ATDNet (G. Anderson and D. Klugmann, 2014). The counting of the registered lightnings is on a unit area of 25 km^2.

The annual number of foggy days varies from 8 to13, in the synoptic stations on the Black sea shore capes, and 50-70, in stations in the Danube plain, the Upper Thracian plain and in high valley fields. High peak synoptic stations were not considered in this study because very often the observers register fog but the peak is actually in a cloudy environment.

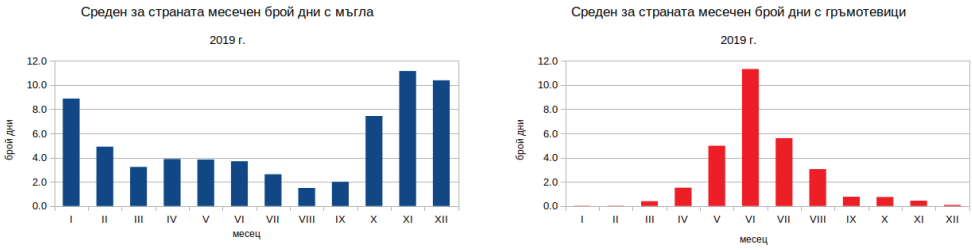


Fig. 18. Mean monthly number of foggy days (left) and thunderstorm days (right) for the whole country for all months of 2019.

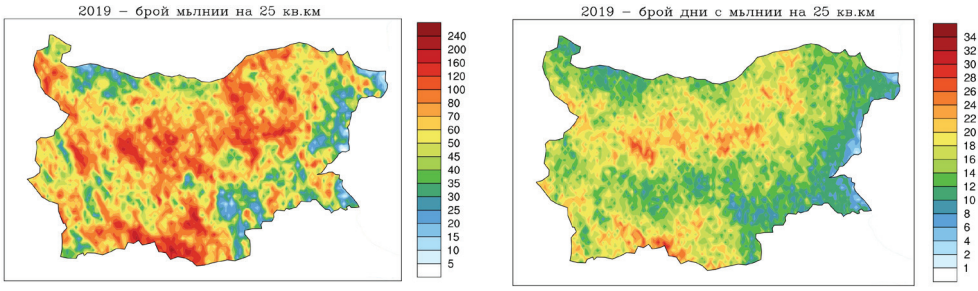


Fig. 19. Annual flash density (left) and annual number of days with registered flashes on 25 km^2 area (right) based on data from ATDNet (G. Anderson and D. Klugmann, 2014).

The annual number of thunderstorm days is between 5-8, in stations on the southern Black sea coast, and 40-54, in stations in Southwest and South central Bulgaria. These statistics are based on the subjective synop data for the weather type. The most thundery month in Bulgaria in 2019 was June with around 270000 registered flashes (data received from ATDNet , G. Anderson and D. Klugmann, 2014). The most thundery day was 24.VI when the number of registered flashes on the territory of the country was above 49000 (Fig. 22a). It was also the most thundery day ever since 2012 in Bulgaria. The previous most thundery month was June 2018 with registered more than 350000 flashes.

The annual number of days with observed hailstorms, in at least one operational station, is 82. December is the only month without registered hail and June is the month with the biggest number of days with hail – 23.

9.2. Cold and hot waves

The first cold wave for the year was in the period 5-9.I. The minimum temperatures fell to –9.9°C on average for North Bulgaria (–20.6°C in Knezha) and to –9.5°C on average for South Bulgaria (–14.8°C in Kyustendil) on 8.I. The very cold weather lasted until 14.I in the Upper Thracian plain and until 18.I in Southwest Bulgaria.

Lasting hot weather was observed during the period 12-28.VI. The maximum temperatures were above 30°C almost everywhere in the lowlands. In some places they stayed above 30°C for 16-17 consecutive days – for example in Ruse, Stara Zagora, and Plovdiv. The daily anomaly of the maximum temperature reached +8.3°C in Dragoman and +9.6°C in Varna.

There were two hot waves in August. The first one, between 7 and 14.VIII., with a duration of 6-8 days. The maximum deviation of the maximum temperature from the daily normal was δT_{max}=+8.4°C in Kyustendil (for South Bulgaria) and +9.1°C in Svishtov (for North Bulgaria). The second heat wave was between 19 and 30.VIII with duration between 6 and 12 days and δT_{max}=+7.9°C in Sandanski (for South Bulgaria) and +8.1°C in Lom (for North Bulgaria). The absolute maximum temperatures, 39°C in Sandanski (South Bulgaria) and 37.7°C in Svishtov (North Bulgaria), were registered on 12.VII.

It is worth noting that in the period 1-18.IX throughout the country were registered prolonged heat waves with maximum temperatures above 30 ° C.

9.3. Significant weather events in 2019

This subsection is devoted to a selection of significant weather events in Bulgaria. They have been selected mainly based on indications for their strength and severity but also their duration and extension. It is not an exhaustive list of significant weather events for the year 2019. The given descriptions have been adapted form texts from the NIMH's Monthly bulletins (see references):

The period of 25-27.I is marked by significant rainfall and snowfall mainly in regions of Southwest and South central Bulgaria. The consequences were swelling rivers, closed roads due to snow piles – a result from drifting snow caused by strong winds, landslides and power cuts. The region of Smolyan in the Rhodopes suffered the most. Many places there stayed cut off for days in snow blockade without power and running tab water. The snow depth was above 1.5 m in some places. The road to Pamporovo and the passes Rozhen and Prevala were closed. There were fallen trees, left-on-the-road out-of-work automobiles, activated landslides. All they interfered the process of cleaning of the roads by the road-maintaining authorities. The village of Mugla and the Astronomical observatory at Rozhen had stayed cut off the longest – for about a week. The weather pattern, associated with this situation, is a southern flow in the middle troposphere and a Mediterranean cyclone sliding to Bulgaria from the south (Fig. 20a). The heavy precipitation is illustrated in Figure 21a and the big snow in the Rhodopes in Figure 21b.

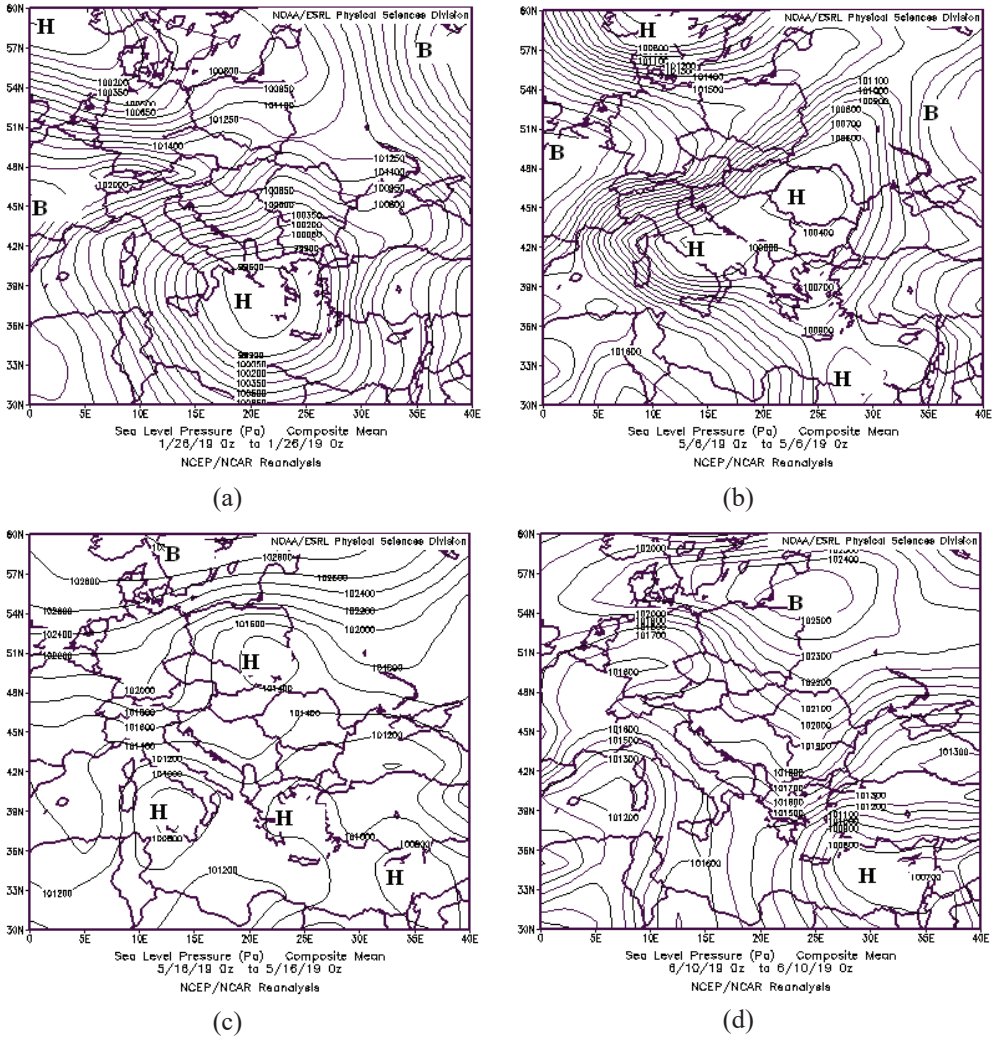


Fig. 20. Sea level pressure (Pa) of the region of Bulgaria on 26.I (a), 6.V (b), 16.V (c), and 10.VI (d) for 0 h UTC.

6.V – Strong afternoon thunderstorms, associated with heavy rain and hail, developed in many places of West, Central, and North Bulgaria. The fields around Pernik and Blagoevgrad were covered with piles of hail grains and, as a consequence, looked like covered with snow. The most severe storm was near the village of Balgare, region of Pleven. There was a hailstorm with hail stones as big as walnuts. Houses and streets in the village were damaged. The crops of wheat, sunflower, corn, and barley , in the lands around the village, were almost totally destroyed. Eyewitnesses reported a case of tornado near the village of Lesnovo but no significant damages were registered. The situation was associated with a cyclonic area passing through the country (Fig. 20b).

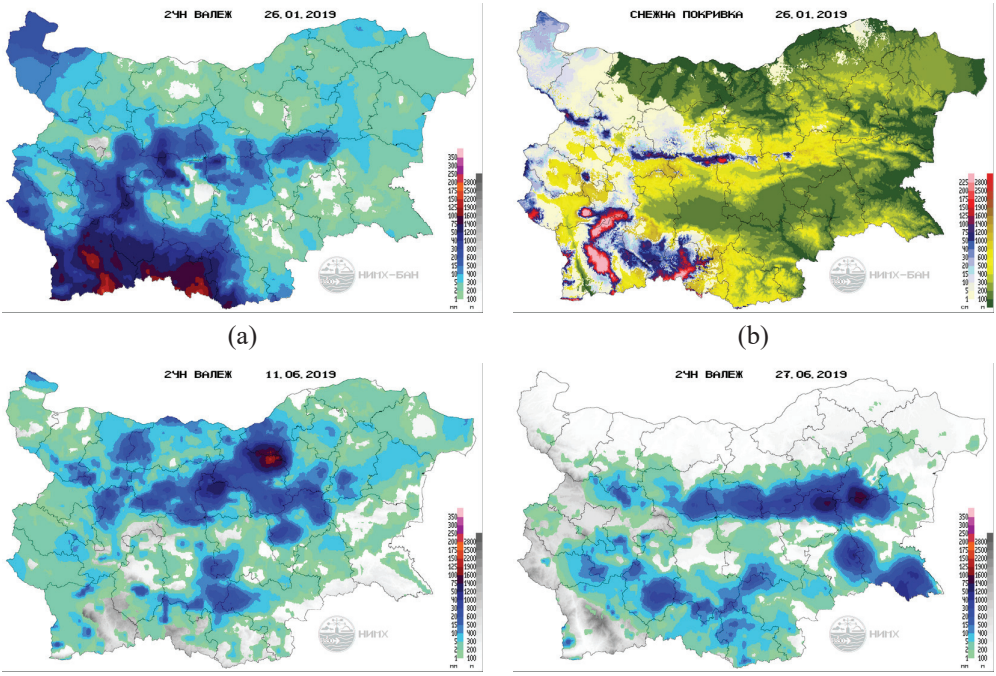


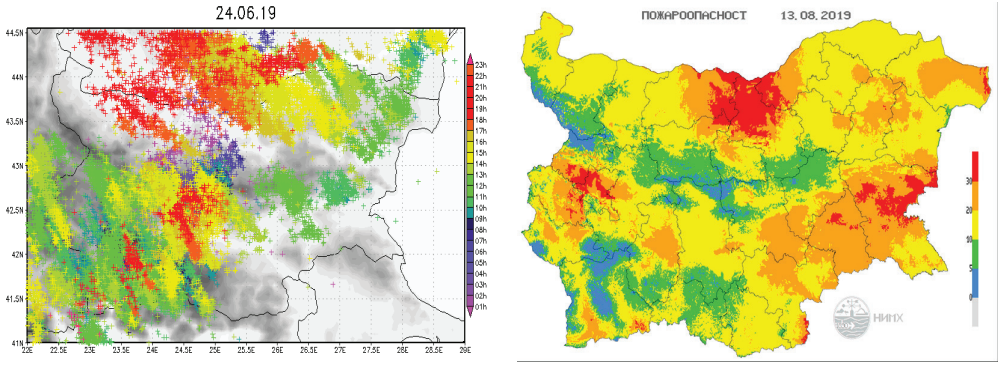
Fig. 21. Daily amount of precipitation (mm) for 26.I (a), 11.VI (c), and 27.VI (d) and snow depth (cm) for 26.VI (b). Left color scale for the precipitation maps – precipitation in mm; right color scale – altitude for the places without precipitation. Color scales for the snow maps as in Fig. 17.

16.V – There were severe hailstorms in the lands around the villages near Karlovo: Karavelovo, Stoletovo, Pevtsite, Bogdan, and Ignatovo. Eyewitnesses reported that the size of the hail stones was comparable to the size of walnuts. The hailstorms lasted more than 10 minutes and damaged severely the vegetable gardens and the vineyards of those villages. A thunderstorm with heavy rain temporarily hindered the traffic on the "Trakia" motorway near Nova Zagora and Stara Zagora. The synoptic map for the day on Fig. 20c reveals a combination of a cyclonic area around Bulgaria and an anticyclone in North Europe.

10.VI – The dike of the dam of Cheshme dere burst and two villages in the municipality of Strazhitsa were flooded. A state of emergency was declared for the villages of Kamen and Nova Varbovka. The amount of precipitation, accumulated within hours, reached more than 100 mm. It is about 140% of the monthly normal. A thunderstorm and a hailstorm damaged thousands of decares of crops in the lands of the municipality of Nova Zagora. The heavy local rains are illustrated in Figure 21c. The synoptic map in Figure 20d shows a cyclonic area in the East Mediterranean and an anticyclone in East Europe.

26.VI – A flash flood happened in the town of Kotel, region of Sliven, due to torrential rains. Some buildings, in the lower parts of the town, were flooded and the local civil-

defense authorities conducted evacuation. The rain caused significant damage of the town's infrastructure. The local big rain in East Stara planina is illustrated in Figure 21d.



(a) (b)

Fig. 22. Registered flashes on 24.VI (left) (color scale hour of occurrence in UTC) based on data from ATDNet (G. Anderson and D. Klugmann, 2014). Fire weather index on 13.VIII (right) (color scale – fire risk level). Maps are derived from the operational archive of products of NIMH.

25-27.I – Synoptic station „Rozhen" (author*: Zh. Ganev – NIMH)*

26.VI – Kotel after the flash flood *(BGNES)*

29.X - High mountain fire in Stara planina *(Facebook)*

The long dry period, with high temperatures in August, led to an increased risk of wildfires (Fig. 22b). There were indeed wildfires in fields near the villages of Bryagovo, Rodopi, and Lyubenovo in the region of Haskovo on 12.VIII. The fire was spreading fast due to strong winds. About 2000 decares of coniferous forest, grass, and bushes were burnt. A forest fire blazed also near Rebrovo, municipality of Svoge, on 18.VIII. Houses and hundreds of decares of mixed forest and bushes were burned. The rugged terrain and the strong winds delayed the extinguishing of the fires until 21.VIII. The relatively dry weather continued in September and October, which maintained the risk of wildfires high until mid autumn. There were local fires in many places through the month of October. The most significant of them were two big forest fires, which were developing simultaneously – one in the western part of Stara planina above the town of Chiprovtsi ant the other in the mountain of Rila, between the hut of Chakalitsa and the

peak of Kapatnik. Their extinguishing was difficult due to the rugged terrain, the high altitude, and the strong winds.

10. CONCLUSION

The target readers of the present publication are the scientists from the wider international scientific community. One of the main meteorological facts for year 2019 is that it fits well the continuing sequence of relatively warm years in Bulgaria. It even appears to be the warmest for Bulgaria since 1930. It is with annual precipitation amounts near or below normal but it is not a very dry year. The number of severe weather events in year 2019 is moderately high. They are evenly distributed though the seasons. There was a case of heavy snow in the Rhodopes at the end of winter, heavy thunderstorms with torrential rains in spring, and wildfires at the end of summer and the beginning of autumn.

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Maps in Figures 1, 2, 15 and 20 are based on the atmospheric reanalysis of Kalnay et al. (1996) and are produced on the website of NOAA-ESRL Physical Sciences Division, Boulder, Colorado, http://www.esrl.noaa.gov/psd/.

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