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Some weather and climate facts for year 2020 in Bulgaria – based on the Annual hydro-meteorological bulletin of NIMH

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Abstract: This is a review paper describing some climate and weather facts for year 2020 in Bulgaria. They are based on meteorological data from the National institute of meteorology and hydrology of Bulgaria, which is its national weather service. The paper is an adapted text from the Annual hydro-meteorological bulletin of NIMH, published in March 2021. The wider meteorological scientific community in Bulgaria and around the world are the target readers. Year 2020 is among the warmest for the last several decades. It is however less warm than year 2019. 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 with print issue ISSN 1314-894X. NIMH issued in March 2020 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. The second edition of the Annual bulletin of NIMH was released in March 2021. It is for year 2020. It has a print issue ISSN 2738-781X.

NIMH created in 2021 a website – http://bulletins.cfd.meteo.bg/ - dedicated to its monthly and annual bulletins. It offers the traditional free access to their latest issues in pdf format. In addition it provides a newly acquired free access to archive of the Monthly bulletin since 2007 together with the later issue of the annual bulletin for year 2019. The electronic bulletins have got their own catalogue numbers for online issues: ISSN 2815-2743 for the Monthly online bulletin and ISSN 2815-2735 for the Annual online one.

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This paper presents an adapted version in English of some of the elements of the meteorological part of the Annual hydro-meteorological bulletin for year 2020. The aim is to reach out to the international scientific meteorological community on the pages of this journal. The information presented is divided in sections devoted to atmospheric circulation and annual summary of the most important meteorological elements such as temperature, precipitation, wind, cloudiness and sunshine, and snow cover as well as statistics for significant events like fog, thunder activity and lightning. 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 maps show deviation from the climate normal. Nevertheless, maps of absolute values are also given for the yearly and the seasonal means in order to provide the reader with an idea of their magnitude. Monthly maps of absolute values can be found in the Monthly hydro-meteorological bulletin of NIMH (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. SOME METEOROLOGICAL FACTS FOR YEAR 2020

Year 2020 is among the warmest for the last several decades. The mean annual temperature, estimated on data from the operational weather stations of NIMH, in average for the country is around 12.4 °C. It is about 0.1 °C lower than the annual Bulgarian temperature of year 2019.

The highest measured maximum temperature is 40.8 °C registered in Lyubimets, region of Haskovo, on 31.VII.

The lowest measured minimum temperature is –20.2 °C registered in the weather station on peak Musala (2925 m) on 6 and 7.II. The lowest temperature, taken in weather stations below 1000 m, is -18.2 °C in Velingrad, region of Pazardzhik, on 8.I.

The annual amount of precipitation is near or below normal. It is slightly bigger than the annual Bulgarian rainfall for year 2019. The biggest daily amount of precipitation is 168 mm from rain. It was registered in Zlatograd, region of Smolyan, on 10.XII.

The strongest wind in populated area with 34 m/s of speed from northeast, was registered in Sliven on 6.I, and on 30.I and 15.XII – from northwest.

The annual number of lightning flashes is around 535 000. It is the lowest annual number for the last 8 years. The day with the highest number of registered lightning flashes in the country was 25.VIII – more than 34 000. 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 2020. The reference period is 1981-2010.

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). They were produced on the website of NOAA-ESRL Physical Sciences Division, Boulder, Colorado, http://www.esrl.noaa.gov. They give an idea of the dominant circulation patterns for each season.

In the winter[1] of 2020 Bulgaria is under the influence of a positive phase of the Northatlantic oscillation (Figure 1a) and the mean seasonal surface pressure is near or above normal (Figure 2a). The spring[2] circulation is dominated by the dipole of high pressure over the British islands and low pressure over the north eastern Europe (Figure 1b) and the mean seasonal surface pressure is near or above normal (Figure 2b). In opposite to spring, the summer[3] circulation is characterized by relatively low pressure over the British isles and relatively high pressure over Eastern Europe (Figure 1c). The mean seasonal surface pressure in Bulgaria is below normal (Figure 2c). Strong anticyclonic circulation centered over Eastern Europe dominates the continent in autumn[4] (Figure 1d) and the mean seasonal surface pressure is near or above normal (Figure 2d).

1 Winter 2020 is the three-month period December 2019 – January 2020 – February 2020. December 2020 will be counted for winter 2021.

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

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

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

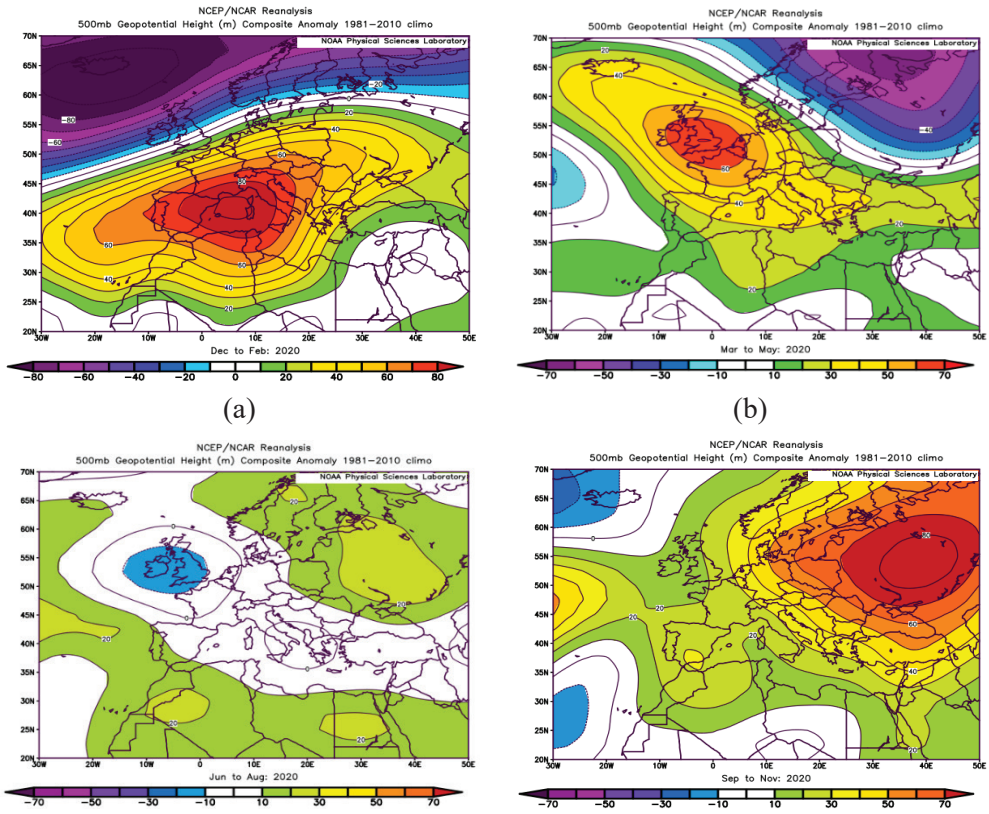
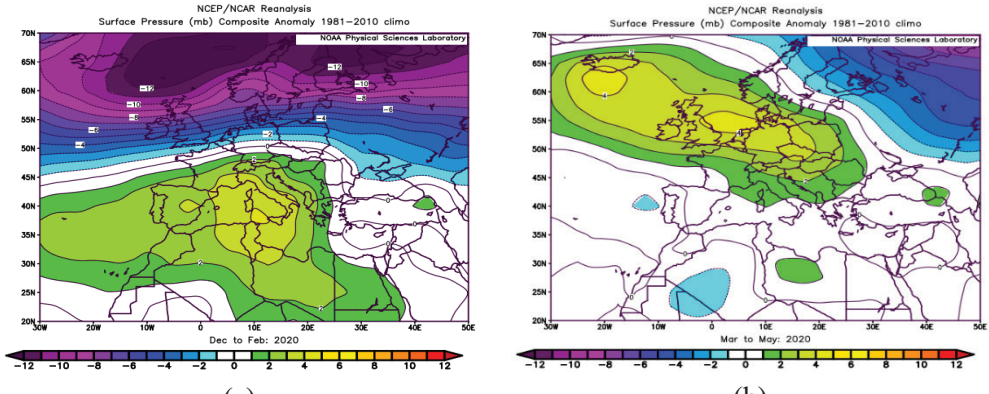
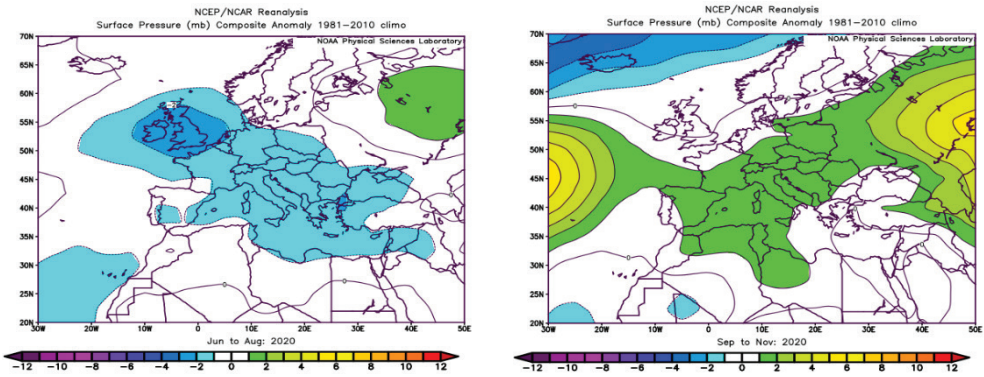


Fig. 1. Deviation of the mean seasonal height (m) of geopotential surface at 500 hPa relative to the seasonal average for 1981-2010 for the four seasons of 2020: (a) – winter; (b) – spring; (c) – summer, and (d) – autumn. Maps are based on the atmospheric reanalysis of Kalnay *et al.* (1996) and they were produced on the website of NOAA-ESRL Physical Sciences Division, Boulder, Colorado, http://www.esrl.noaa.gov/psd/.





(c) (d)

Fig. 2. Deviation of the mean seasonal surface pressure (mb) from the normal for 1981-2010: (a) – winter; (b) – spring; (c) – summer; (d) – autumn. Maps are based on the atmospheric reanalysis of Kalnay *et al. (1996).* They were produced on the website of NOAA-ESRL Physical Sciences Division, Boulder, Colorado, http://www.esrl.noaa.gov/psd/.

4. TEMPERATURE

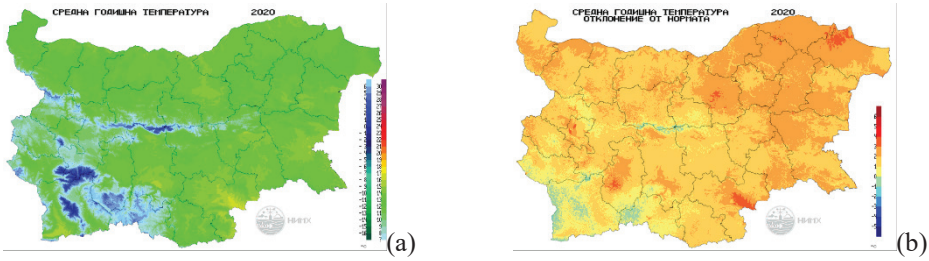
Figure 3 shows maps of the mean annual temperature for year 2020 (a) and its deviation from normal (b). Figure 4 shows maps of the mean seasonal temperature and its deviation from normal for the four seasons. Figure 5 shows maps of the deviation from normal of the mean monthly temperature for all 12 months of 2020.

The mean annual temperature[1] is around 12.4 °C. It is about 0.1 °C lower than the annual temperature of year 2019. Year 2020 is among the few warmest for the last several decades.

Winter is the warmest season relative to the norm. This fact can be verified in Figure 4. The winter of 2020 is among the top warmest winters since 1951. Spring is with temperatures near normal. Summer is warmer than normal but cooler than the summer of 2019. Autumn is also warmer than normal and can be positioned among the top warmest autumns since 1951.

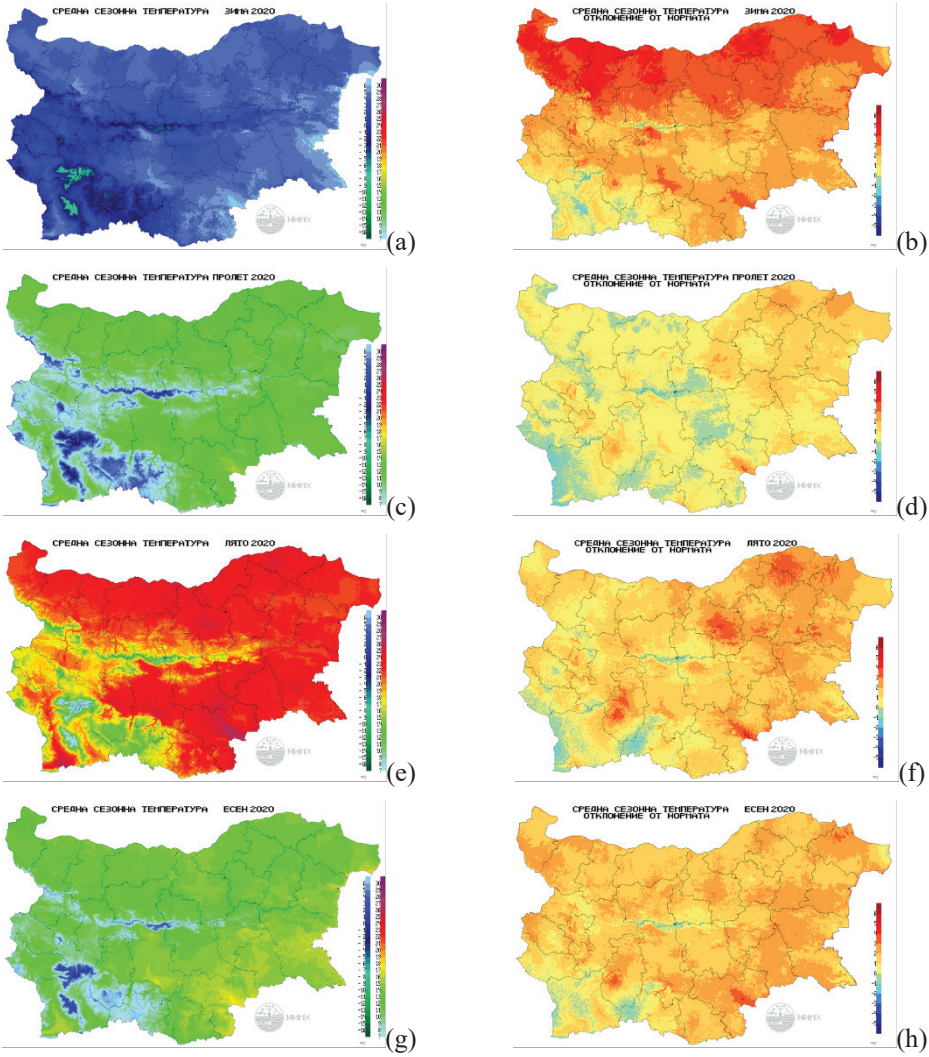
The annual highest maximum temperature is 40.8 °C registered in Lyubimets, region of Haskovo, on 31.VII. The annual lowest minimum temperature, in stations below 1000 m of altitude, was –18.2 °C, measured in Velingrad, region of Pazardzhik, on 8.I. However, the lowest of all measured minimum temperatures, – 20.2 °C, was registered on peak Musala (2925 m above sea level) on 6 and 7.II.

1 The mean annual temperature is based on operational data.



(a) (b)

Fig. 3. Mean annual temperature (°C) for 2020 – (a) and its deviation from normal – (b).



(a) (b) (c) (d) (e) (f) (g) (h)

Fig. 4. Mean seasonal temperature (°C) (left) and its deviation from normal (°C) (right) for the four seasons of 2020: (1st row) – winter; (2nd) – spring; (3rd) – summer; and (4th) – autumn.

The coldest months relative to normal are April May, June, and November with monthly mean temperatures near normal. The warmest months relative to normal appear to be February and September which are among the top 10 warmest months of February and September respectively since 1951. These facts can be infurred from Figure 5. Figure 6 illustrates the evolution through the year of temperature relative to normal for major cities. The temperature begins above normal in winter months but goes around normal in spring. It is prominently above normal in summer and the beginning of autumn and cools down in later season.

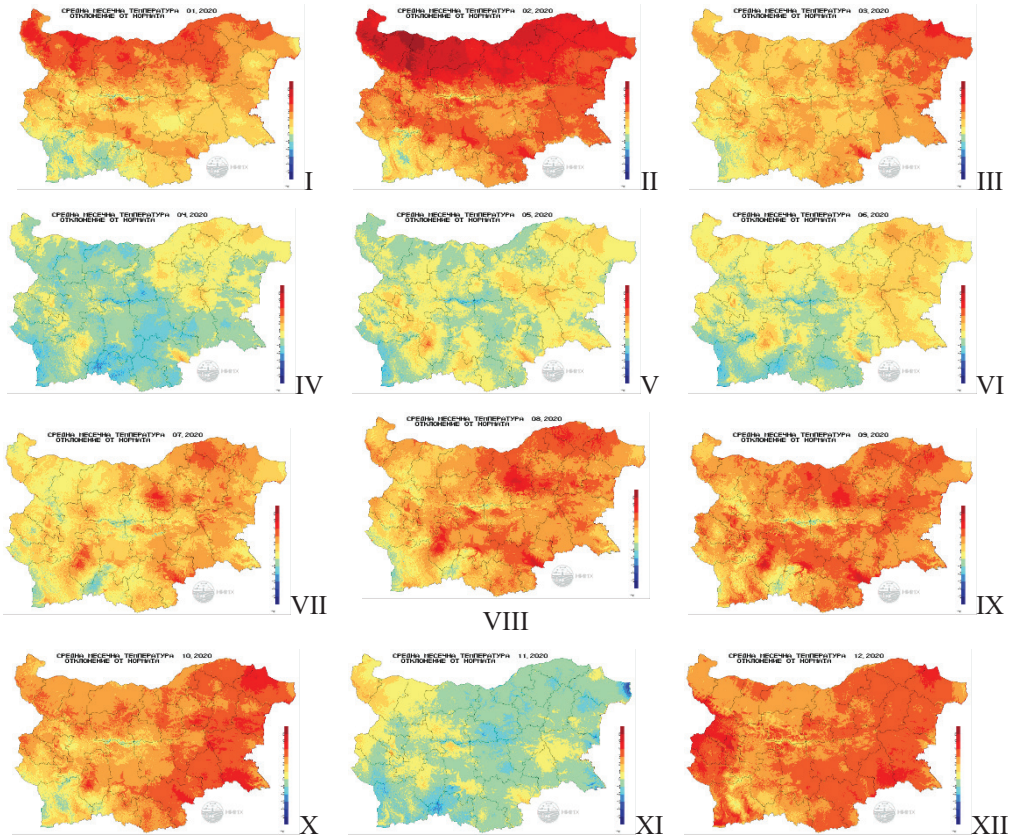


Fig. 5. Mean monthly temperature (°C) as deviation from normal (°C) for all months of 2020.

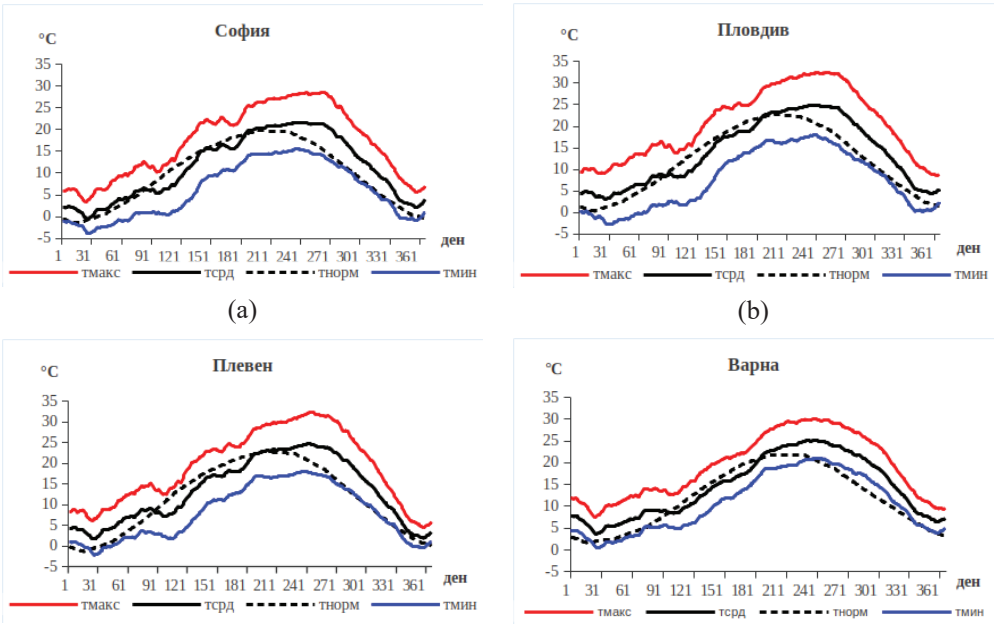


Fig. 6. Annual temperature trend (°C) as 30-day running average for major cities – Sofia (a); Plovdiv (b); Pleven (c); Varna (d)

5. PRECIPITATION

Figure 7 shows the annual amount of precipitation for year 2020 in absolute values and in percent of normal. Figure 8 shows the seasonal amount of precipitation in absolute values and in percent of normal for the four seasons. Figure 9 shows the monthly amount of precipitation in percent of normal for all months of 2020.

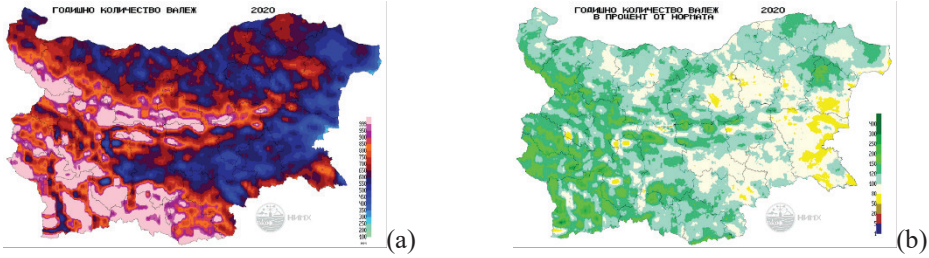


Fig. 7. Annual amount of precipitation (mm) (left) and in percent of normal (right)

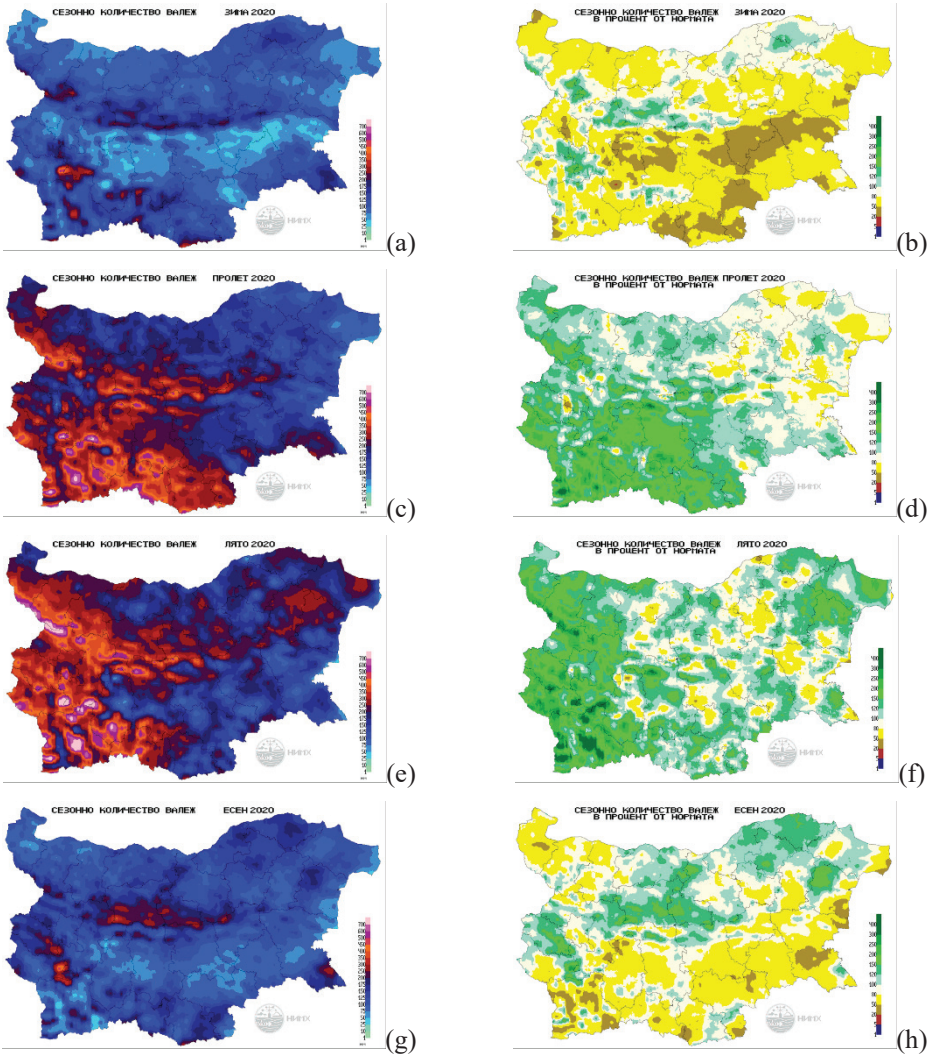
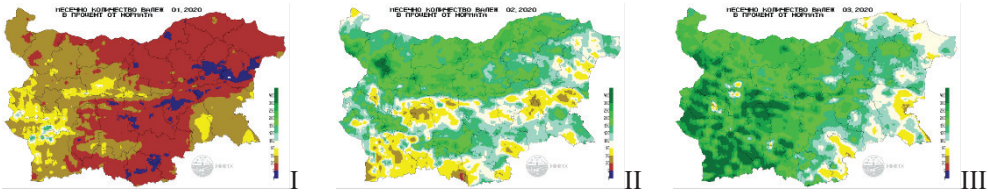


Fig. 8. Seasonal amount of precipitation (mm) (left) and in percent of normal (right) for the four seasons of 2020; (1st row) – winter; (2nd) – spring; (3rd) – summer; (4th) – autumn



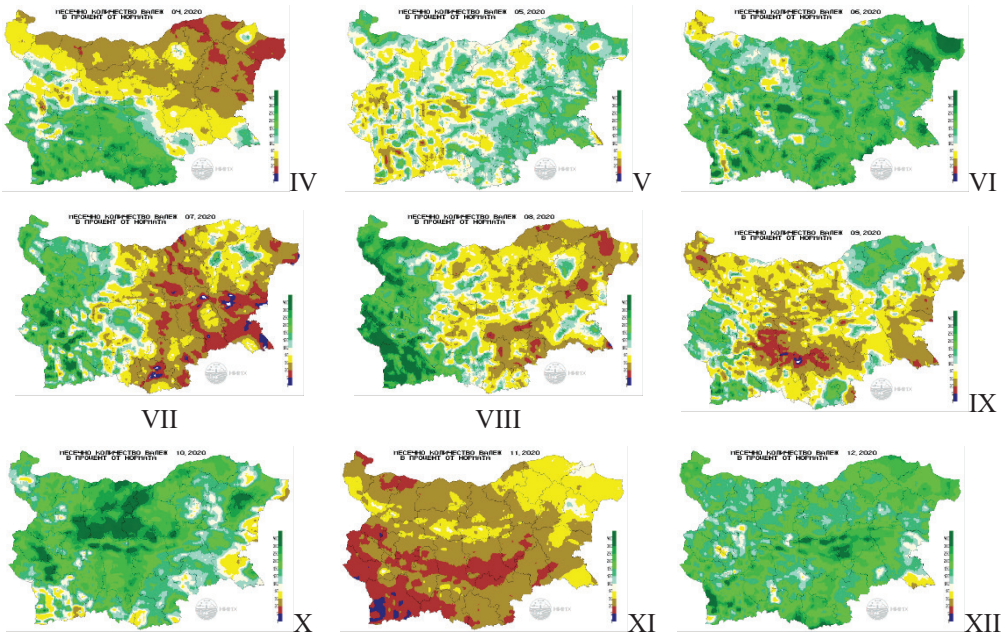
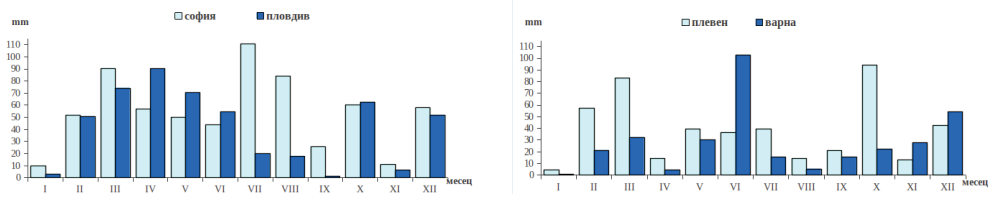


Fig. 9. Monthly amount of precipitation in percent of normal for all months of 2020

The annual amount of precipitation for year 2020 is near normal. It is bigger than the annual rainfall for year 2019.

Spring is the wettest of all calendar seasons of year 2020 (Figure 8) especially in Southwest Bulgaria. It is followed by summer but both are around normal in average. Winter is very dry especially in Southern Bulgaria. Autumn is also dry there but to a lesser degree. Both are the driest winter and autumn respectively for the last several years.

The wettest months relative to normal are December, March, February, and October. The driest are January, November, July, and April (Figure 9). December seems to be the wettest for the last several years and January – the driest for the last couple of decades.



(a) (b)

Fig. 10. Monthly amount of precipitation for all months of 2020 for major cities: Sofia and Plovdiv (left); Pleven and Varna (right)

The biggest daily amount of precipitation is 168 mm from rain. It is registered in Zlatograd, region of Smolyan, on 10.XII.

Figure 10 shows diagrams of the monthly amounts of precipitation for all months of year 2020 for Sofia, Plovdiv, Pleven, and Varna.

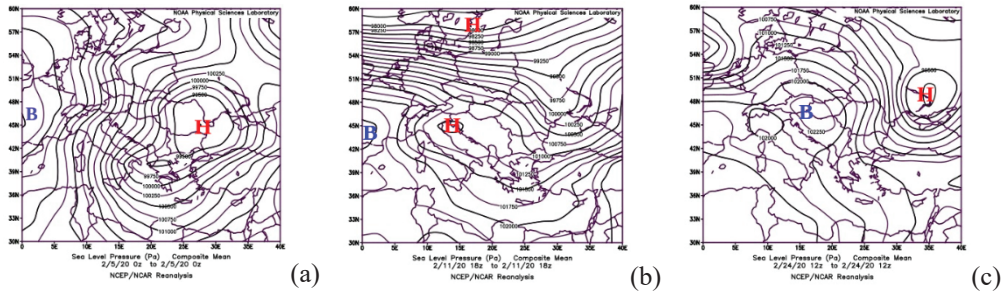
6. STRONG WIND

Table 1 contains a list of the days with strong wind in 2020. A day with strong wind, for the purpose of this analysis, is defined as a day in which the number of operational stations of NIMH with strong wind[1] is greater than 20.

Table 1. Strong wind data for year 2020

Month	Day	Number of stations with strong wind	Month	Day	Number of stations with strong wind	Month	Day	Number of stations with strong wind
I	4	21	II	11	37	IV	6	33
I	5	26	II	24	72	V	6	23
I	6	32	II	26	26	V	12	21
I	22	25	II	27	43	V	20	23
I	29	30	II	28	23	VII	7	31
I	30	24	III	3	32	VIII	7	28
II	3	36	III	4	21	VIII	8	33
II	4	45	III	15	23	IX	26	32
II	5	42	III	23	23	X	13	37
II	6	28	III	24	30	X	30	26
II	7	23	IV	5	40	XII	28	22

Figure 11 shows maps of the sea-level pressure in the six days with the greatest number of stations with strong wind from Table 1.



1 The wind is classified as "strong" if its maximum speed is equal or greater than 14 m/s.

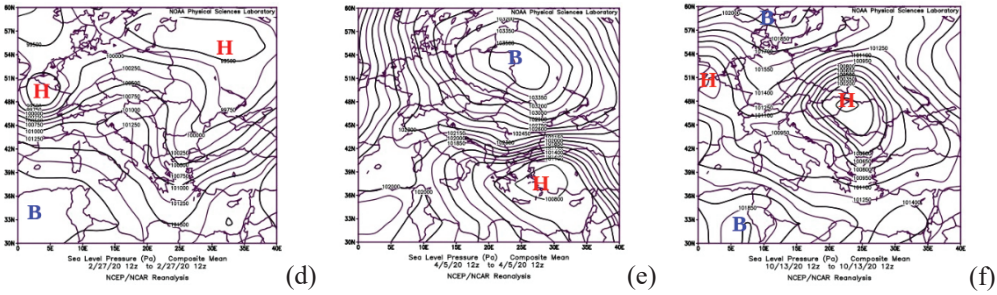


Fig. 11. Mean sea level pressure (Pa) on: (a) 5.II, 0 h Coordinated Universal Time (UTC); (b) 11.II, 18 h UTC; (c) 24.II, 12 h UTC; (d) 27.II, 12 h UTC; (e) 5.IV, 12 h UTC; (f) 13.X, 12 h UTC. Maps are based on the atmospheric reanalysis of Kalnay *et al. (1996).* They were produced on the website of NOAA-ESRL Physical Sciences Division, Boulder, Colorado, http://www.esrl.noaa.gov/psd/

The following is a set of descriptions of the synoptic situations for these days:

4-5.II: A cyclone goes through the Balkans. There is a cold frontal system associated with it. A new vortex forms in the Aegean sea on 5.II which consequently crosses the Black sea (Figure 11a). The strong winds are from northwest in the Danube plain, the Upper Thracian valley, and Eastern Bulgaria. Registered speeds are above 20 m/s in many stations. Sliven for example reported 34 m/s.

11.II: Bulgaria is in the southern periphery of a large cyclonic area over Northern Europe (Figure 11b). The frontal zone associated whit the cyclone lays over the country. There are strong western winds in much of the country but mostly in the Danube plain and Eastern Bulgaria.

24.II: There is a northwestern cold front crossing the country. It is associated with a cyclone centered north of Black sea (Figure 11c). There are strong northwestern winds in many places. The speeds exceed 20 m/s in the Danube plain and Eastern Bulgaria.

27.II: Another cold front passes through (Figure 11d) which brings again strong northwestern winds mostly in the Danube plain and Eastern Bulgaria.

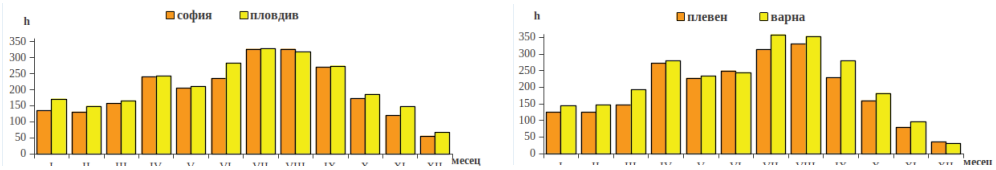
5.IV: The strong wind case of 5.IV is associated with a Mediterranean cyclone passing south of Bulgaria. It is coupled with an anticyclone positioned to the north of the country over Central Europe (figure 11e). The strong winds come from northeast and are common in Eastern Bulgaria where the registered speeds are often above 20 m/s.

13.X: The synoptic pattern on 13.X is dominated by a cyclone going northward through the Western Balkans. It is associated with a cold front brushing Bulgaria from the west. There are strong southwestern foehn winds in Northwestern Bulgaria but also strong southeastern winds in stations in Southeastern Bulgaria. The mechanism of these strong winds is related to different stages of the evolution of the cyclone to the west of the country. Kardzhali reported 33 m/s.

7. CLOUDINESS AND SUNSHINE

The mean annual amount of cloudiness, evaluated in the stations of NIMH, is between 4 and 6.5 tenths which is around normal. The annual number of clear-sky days, registered in the stations of NIMH, is between 39 and 139 which is around normal in a wide interval. The annual number of cloudy days is between 48 and 155 which is also around normal in a wide interval.

Figure 12 shows diagrams of the monthly duration of sunshine for all months of 2020 for Sofia, Plovdiv, Pleven, and Varna.



(a) (b)

Fig. 12. Monthly duration of sunshine (hours) for all months of 2020 for major cities: Sofia and Plovdiv (left); Pleven and Varna (right)

8. SNOW COVER, GLAZE ICE, AND FROST

There are four significant snow events in 2020:

5-6.II: There is snowfall in the bigger part of the country except parts of the Southern and Northwestern Bulgaria. In many places in the Danube plain, the Predbalkan, and the Western Rhodopes the snow depth is between 30 and 60 cm (Figure 13a). Southeastern Bulgaria has the snow on 7-8.II.

22-24.III: During this period there is significant snowfall in Northern, Western and central Southern Bulgaria. In places, mostly in Western Bulgaria, the snow depth reaches 10-22 cm (Figure 13b).

31.III-2.IV: There is again a snowfall in Northern and Western Bulgaria as well as in the mountains of Rila and Rhodopes on 31.III. On 1-2.IV the snow falls in Western and Central Bulgaria except the central part of the Danube plane and parts of the Upper Thracian valley (Figure 13c).

29.XI-1.XII: In the last days of November snow covers the western regions of Pernik and Sofia, the Predbalkan, central Northern and Northeastern Bulgaria (Figure 13d).

The biggest snow depth, registered in operational stations of NIMH, is measured in the village of Manastir (1500 m above sea level) in the region of Smolyan on 8.II – 105 cm. From stations on a mountains tops, the biggest snow depth is measured at Cherni vrah (2290 m above sea level) on 7.IV – 128 cm.

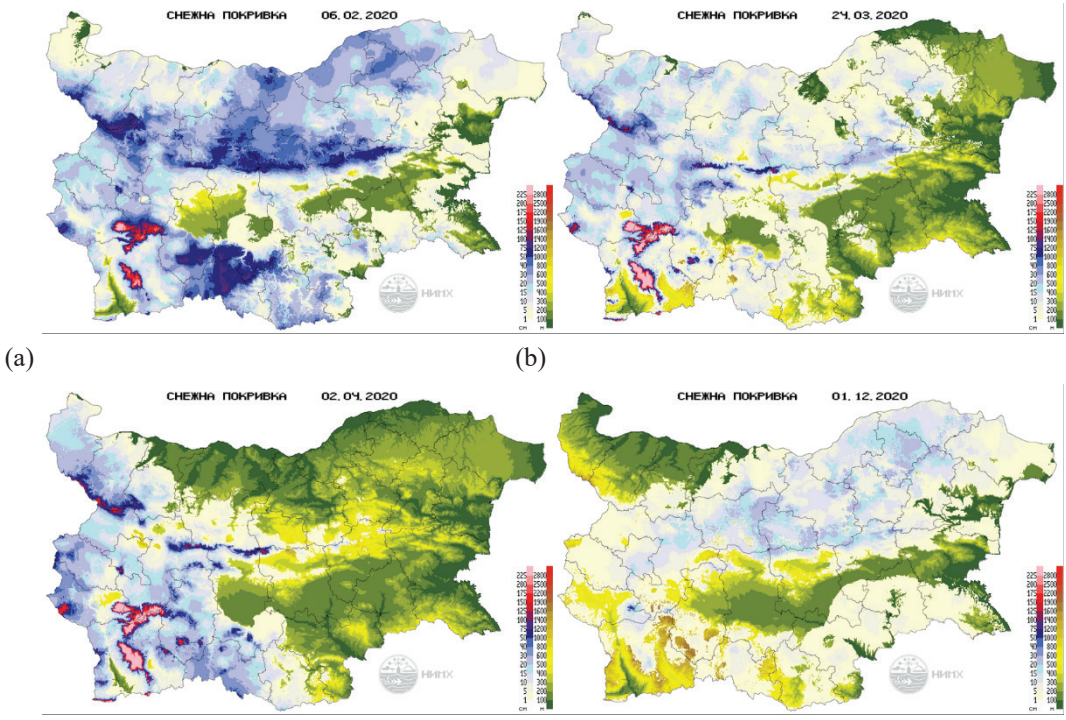


Fig. 13. Snow depth analysis for 6.II (a), 24.III (b), 2.IV (c), and 1.XII (d). Left color scale – snow depth in cm; right color scale – altitude in meters

The following are the cases with observed freezing rain and glaze ice in 2020:

In the period of 17-18.I, there are stations reporting freezing rain or glaze ice in Northwestern Bulgaria. Between 6 and 10.II such cases are reported in Eastern Bulgaria. In the period 3-5.XII there are glaze ice conditions in places in Western Bulgaria and in the period 8-10.XII – at stations in Eastern and Northwestern Bulgaria.

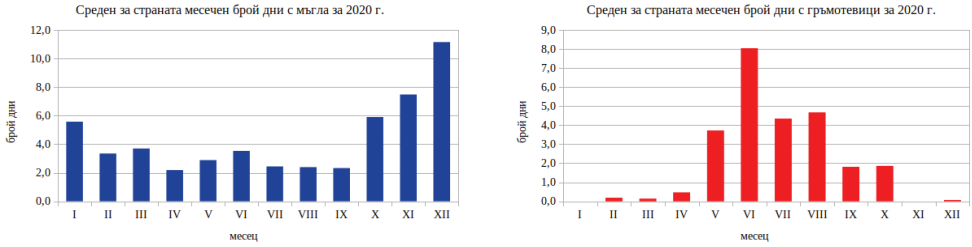
The frost is a meteorological phenomenon that occurs in the cold seasons but is considered critical only in the transitional months of September-October and April-May. In year 2020, in these transitional months, there is a number of cases with frost conditions:

In April, the periods with frost in many places countrywide are: 3-4.IV, 7-13.IV, 16-18.IV, and 23-25.IV. There are days with frost in the months of May and September too but only in stations at higher-ground fields. The period with frost in many stations in October is 19-24.X.

9. SIGNIFICANT WEATHER

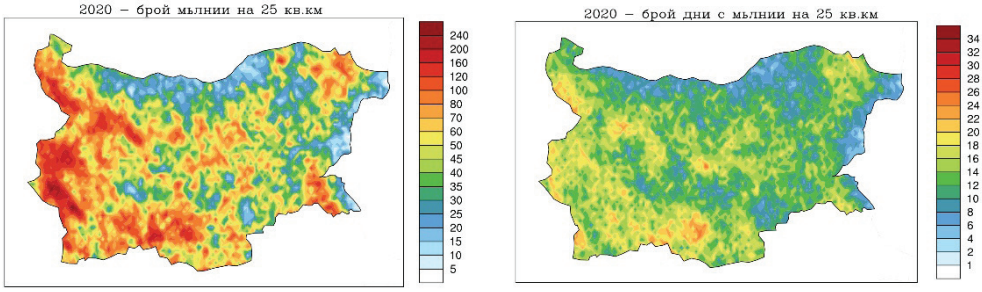
Figure 14 shows the countrywide monthly mean number of days[1] with fog and thunder activity. It is based on the operational data from the synoptic stations of NIMH. The presence of thunder activity is subjectively determined by the observers in these stations. All cases with thunder activity in the vicinity or far from the station, or with observed only lightning without thunder, are taken into account. Figure 15 shows spatial distribution of the annual number of lightning flashes and the annual number of days with flashes. They are based on data from ATDNet (G. Anderson and D. Klugmann, 2014). The registered flashes are count per 25 km^2.

The least annual number of foggy days is between 9 and 29 in the synoptic stations on the Black sea shore capes. The highest number of foggy days is around 63, in stations in higher-ground fields. The synoptic stations on mountain tops are not taken into account for these statistics because they fall among clouds very often which is reported in synop telegrams as fog.



(a) (b)

Fig. 14. Mean monthly number of foggy days (left) and thunderstorm days (right) for all months of 2020



(a) (b)

Fig. 15. Annual flash density (left) and annual number of days with registered flashes on 25 km^2 (right) based on data from ATDNet (G. Anderson and D. Klugmann, 2014)

1 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 data is associated.

The annual number of lightning flashes in Bulgaria is around 535 000. It is the lowest annual number for the last 8 years. The most thundery month in Bulgaria in 2020 is June with around 175 000 registered flashes (data received from ATDNet ,G. Anderson and D. Klugmann, 2014). It is followed by August with around 150 000 flashes. The most thundery day is 25.VIII where the number of registered flashes within the territory of the country is above 34 000 (Figure 16).

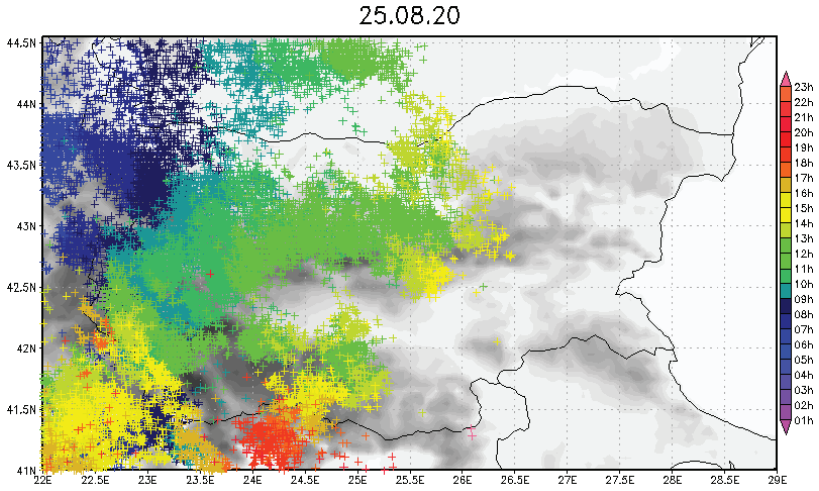


Fig. 16. Registered lightning flashes on 25.VIII from ATDNet. Color scale – UTC hour of occurrence.

The annual number of days with observed hailstorms in at least one operational station is 64. June is traditionally the month with the biggest number of hail days – 21. The months without registered hail in operational stations are January, March, November and December. The day with the biggest number of operational stations with registered hail is 29.V – 27. Table 2 presents statistics of the monthly number of hail days and the monthly number of hail cases in operational stations.

Table 2. Monthly number of days and monthly number of cases with hail in 2020 (based on operational data).

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Number of days	0	2	0	3	13	21	10	8	3	4	0	0
Number of cases	0	10	0	10	113	118	24	20	10	19	0	0

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 2020 is that it fits well the continuing sequence of relatively warm years in Bulgaria. Similarly to year 2019 it even appears to be among the warmest years in Bulgaria for the last several decades. It is with annual precipitation amounts near or below normal It is slightly wetter than year 2019 and similarly it is not a very dry one. It is the least thundery of the last 8 years.

ACKNOWLEDGMENTS

The observation of the weather events and their parameters, the collection and the archiving of the data and their processing are only possible thanks to the work of the hundreds of meteorological observers, information-technology experts, archivists, scientists and all other staff of the National Institute of Meteorology and Hydrology – the Bulgarian hydro-meteorological service.

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