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# Brief climate analysis and extreme weather events in Bulgaria during 2020

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**Abstract:** This review paper presents a brief climate assessment of temperature and precipitation conditions and extreme weather events during 2020 in Bulgaria, based on data from the meteorological network of the National Institute of Meteorology and Hydrology (NIMH) but also from other sources of information. According to our analysis, 2020 was the second warmest year since 1930 in Bulgaria, while the mean annual precipitation was about climate normal. Main extreme meteorological and agrometeorological events during the year are also presented.

**Keywords:** climate, extreme events, dust, drought

## 1. INTRODUCTION

Every year, the NIMH prepares two main materials, briefly presenting the climatic features and the observed extreme meteorological phenomena in Bulgaria over the past year. These analyzes are the contribution of our country to two annual publications supported by the World Meteorological Organization (WMO). The first one is "BAMS State of the Climate" (https://www.ncdc.noaa.gov/bams), which is an extensive review of the global climate. The second one is the "Annual Bulletin of Climate in WMO Region VI" (https://www.dwd.de/rcc-cm), which is more detailed than the BAMS report regarding regional analyses. In both editions, the information presented for each country is greatly abbreviated or used only for generalized descriptions of the climatic features of the individual regions. In Bulgaria, 2020 was the second warmest year since 1930, with many different extreme weather events such as droughts, hot periods, strong convective storms, local floods, and more. We believe that a more detailed analysis

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of all these events will be of interest to a wide audience of readers from the scientific community and students, amateur meteorologists, and ordinary citizens. That is why we decided to present the full texts prepared for the WMO publications. Some materials from the NIMH's monthly and annual hydrometeorological bulletin were also used (http://bulletins.cfd.meteo.bg).

The brief climate analysis is prepared on data from the 42 synoptic and 78 climatological stations from the meteorological network of the National Institute of Meteorology and Hydrology (see Figure 1). We considered the period after 1930 because the meteorological network of Bulgaria already had a sufficiently good spatial distribution and was representative of all climatic regions of the country. Temperature and precipitation normals are defined as the 1961–1990 averages.

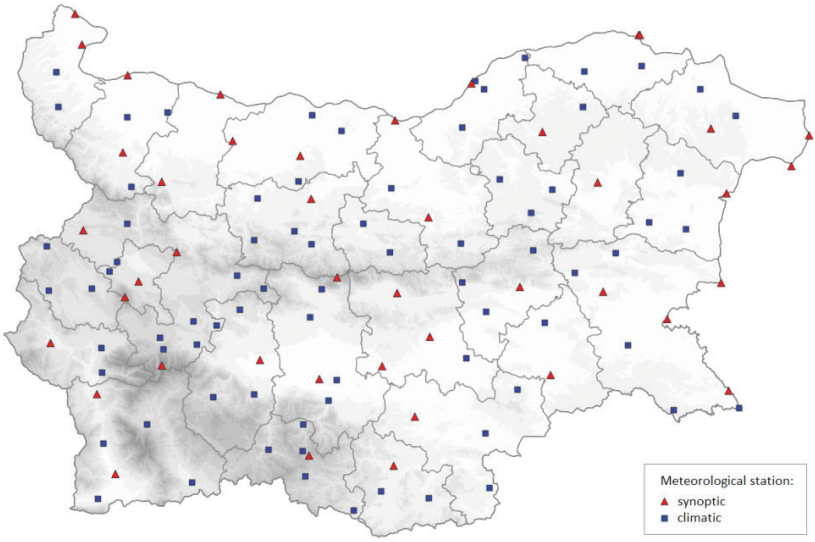



**Fig. 1.** Spatial distribution of the meteorological stations used in the survey: synoptic (red squares) and climatological (blue triangles)

## 2. BRIEF ANALYSIS OF TEMPERATURE AND PRECIPITATION

In 2020 the average annual air temperature for the low parts of Bulgaria (up to 800 m altitude) had increased by 1.9 °C to the climate normal that arranges the year as the second hottest since 1930 (Figure 2). According to the monthly temperature anomaly, the warmest month was February with a deviation range (+1.9 °C to +7.2 °C), followed by December (+1.7 °C to +5.1 °C) and September (+1.2 °C to +5.3 °C). The coldest months were April (–2.6 °C to +1.6 °C) and November (–2.0 °C to +2.0 °C).

The winter was the third warmest since 1930, with a temperature anomaly of +2.9 °C. December 2019 was warm with an average anomaly of +3.0 °C in North Bulgaria

(+4.0 °C in Krushari, Dobrich District) and +1.8 °C in South Bulgaria (+3.2 °C on Cape Emine). January 2020 was also warm, with deviations of +3.1 °C on average in North Bulgaria and +1.7 °C on average in South Bulgaria. In February 2020, the temperature anomaly reached +4.7 °C in North Bulgaria (+7.2 °C in Knezha, Pleven District) and +3.1 °C in South Bulgaria (+4.4 °C in Velingrad, Pazardzhik District). The lowest minimum temperatures registered in January were –10.4 °C in North Bulgaria (Vidin District) and –11.6 °C in South Bulgaria (Sofia and Stara Zagora districts). No prolonged cold spells have been observed.

Spring was +0.9 °C warmer than normal. After warm March with an average anomaly of +2.3 °C (up to +4.0 °C in Krushari, Dobrich District), the season continued with cooler weather during April. Negative temperature anomalies were registered in almost entire South Bulgaria (down to –2.6 °C in Hisarya, Plovdiv District) and some regions in North Bulgaria (–2.3 °C in Oryahovo, Vratsa District; –2.2 °C in Gabrovo). Negative anomalies of daily minimum temperature took place roughly to the end of the month, forming 10- to 13-day periods (up to 18 days in Plovdiv). May was slightly warm, but negative anomalies were registered in some regions in North Bulgaria and Eastern Rhodopes (–1.4 °C in Vratsa District; –0.8 °C in Kardzhali District).

The average summer anomaly is +1.7 °C. June was slightly warm with a deviation of +0.9 °C in North Bulgaria (+2.4 °C in Dalgopol, Varna District) and +0.5 °C in South Bulgaria (+2.5 °C in Kotel, Sliven District). However, negative anomalies were registered in some regions in North Bulgaria (–1.3 °C in Gabrovo), Eastern Rhodopes (–1.6 °C in Kardzhali), and South-West Bulgaria. July temperature anomaly was +1.8 °C (up to +4.0 °C in Velingrad, Pazardzhik District). August was +2.8 °C warmer than normal in North Bulgaria (+4.3 °C in Omurtag, Targovishte District) and +2.5 °C in South Bulgaria (+4.8 °C in Velingrad, Pazardzhik District).

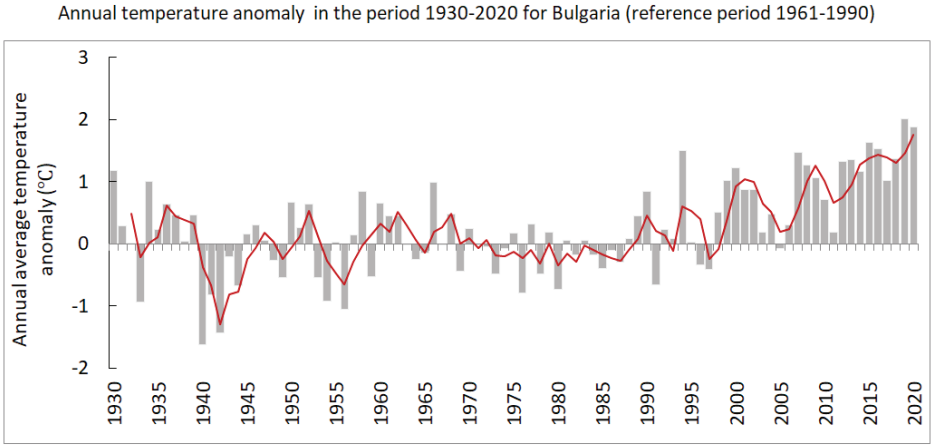



**Fig. 2.** Deviation of the country's average annual air temperature from the climate normal for the period 1930-2020; the red line represents the 3-year moving average.

Autumn was +1.9 °C warmer than normal. The season was the fourth warmest since 1930. September temperature anomaly was +3.0 °C (+4.9 °C in Knezha, Pleven District and +5.3 °C in Velingrad, Pazardzhik District). In the period 1-15 September, a prolonged hot spell with a maximum temperature over 30 °C was registered over the whole country. October temperature anomaly was +3.0 °C in North Bulgaria and +2.6 °C in South Bulgaria (up to +4.7 °C in Krushari, Dobrich District and Malko Tarnovo, Burgas District). November was cooler than normal. Negative temperature anomalies were registered in almost entire South Bulgaria (down to –1.3 °C in Krumovgrad, Kardzhali District) and the central and eastern parts of North Bulgaria (down to –2.0 °C in Gabrovo).

December 2020 was the third warmest since 1930, with an average anomaly of +3.0 °C in North Bulgaria (+4.3 °C in Knezha, Pleven District) and +3.5 °C in South Bulgaria (+5.1 °C in Sofia).

The average annual precipitation in the areas up to 800 m was about normal (94% of the climate normal) without considerable difference between North and South Bulgaria. Figure 3 shows the deviation from the climate normal of the annual precipitation sums for the period 1930-2020. Seasonal precipitation amounts were: 67% of the climate normal in the winter (12 drier since 1930), 111% in the spring, 92% in the summer, and 86% in the autumn (14 drier since 1930). Spring and summer seasonal precipitation was about normal but unevenly distributed over the country. At the end of spring and during the summer months in West and Central Bulgaria, the precipitation amounts mainly were about or over climate normal, while in eastern parts of the country, they were insignificant.

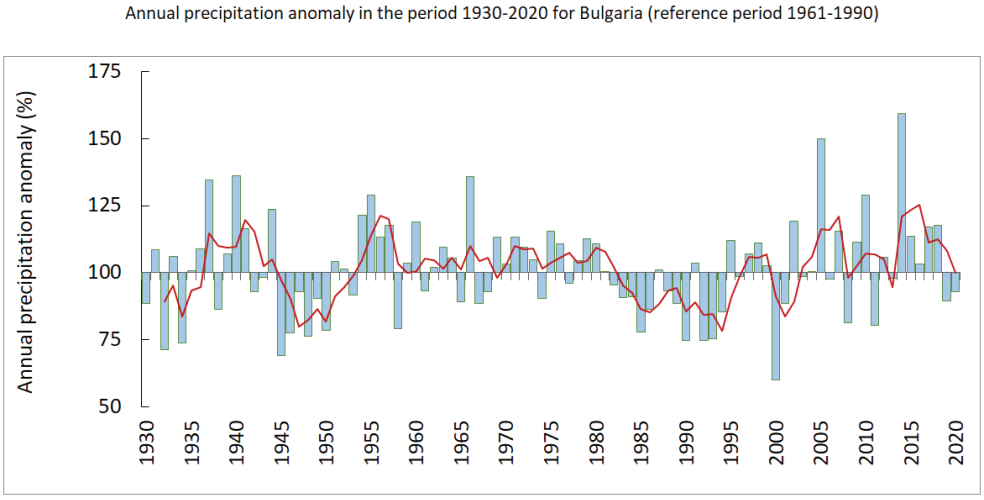



**Fig. 3.** Deviation of the country's average annual precipitation from the climate normal for the period 1930-2020; the red line represents the 3-year moving average

The rainiest month was March, with average precipitation about 1.6 times more than monthly normal (up to 335% in Tran, Pernik District), followed by December – 1.5 times more than monthly normal (up to 314% in Sadievo, Sliven District). The driest months were January (fourth driest since 1930) and November (third driest since 1930) with 20% and 33% from the normal, respectively. The largest precipitation anomaly was registered in August – 411% in Blagoevgrad. The annual maximum 24-hours precipitation amount of 168 mm was measured in Zlatograd, Smolyan District, on 10 December.

## 3. EXTREME WEATHER EVENTS

### 3.1. Heat and cold waves, frost, drought, fires and agrometeorological impact

Although the winter of 2020 was mild, several episodes with very low spring temperatures caused significant damage to some crops. On March 16-17, low temperatures ( –3 °C to –8 °C) were registered, critical for the fruits that have entered the flowering phase. Serious frost damage (50-90%) to the apricot trees was registered in Northeastern Bulgaria (districts of Targovishte and Silistra). Three cold spells were registered during April 2020: 1) 1-3 April, with an average anomaly of the minimum temperature of –6.7 °C in North Bulgaria and –5.9 °C in South Bulgaria; 2) 6-10 April, with an average anomaly of the minimum temperature of –6.1 °C in North Bulgaria and –4.5 °C in South Bulgaria; 21(22)-25 April – unusually late cold spell when minimum temperatures dropped below zero in many districts (Vidin, Pleven, Shumen, Burgas, Yambol, Haskovo, and Kyustendil) and well below zero in Dobrich District (–3.9 °C) and Stara Zagora District (–2.9 °C).

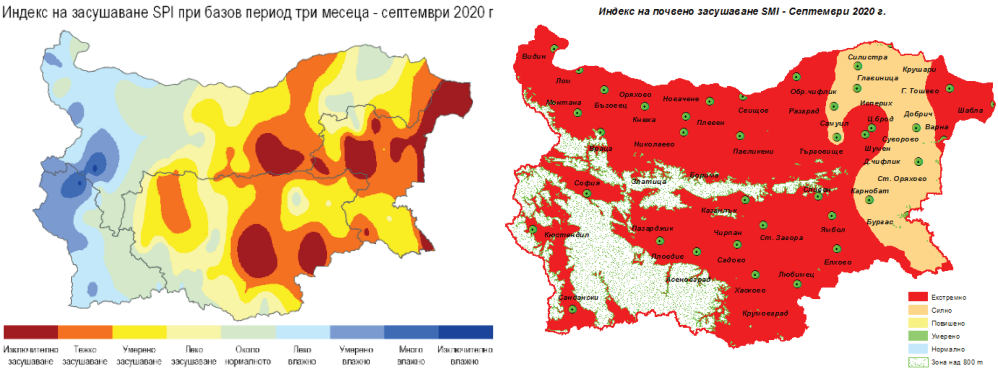
Significant frost damages were registered during the cold spells in April 2020. In the first decade of the month, between 20% and 70% of the early flowering orchards (cherries, apricots and peaches) in Razgrad, Sofia, Kyustendil, Plovdiv, Pazardzhik, and Silistra districts were damaged by the cold. At the beginning of the third decade, negative minimum air temperatures between –0.8 °C to –3.9 °C in Vidin, Dobrich, Stara Zagora, Kazanlak, and Yambol caused damage to 20% of orchards over an area of 16 000 км$^2$. Unusual damages to the winter wheat caused by weather events were registered during March and April in the regions Dobrich and Karnobat. The reason is that recurrent frosts at the resuming of spring vegetative growth (Dobrich) and the beginning of the booting stage (Karnobat) caused damage to the winter wheat (Mihova. G., 2021).

Prolonged hot spells (6-18 days) with a maximum temperature ≥ 32 °C were registered across the country from 26 June to 3 September. In Ruse, Yambol, Haskovo, Stara Zagora and Blagoevgrad districts, the total number of days in hot spells exceeds 30 (up to 53 days in Elhovo). Consecutive heat waves, as well as significantly below normal precipitation, caused severe weather conditions. Extremely hot 5- to 10-day spells with maximum temperatures ≥ 34 °C were registered in the districts of Veliko Tarnovo,

Russe, Yambol, Haskovo and Stara Zagora. The maximum summer temperatures, both in southern and northern parts of the country, were observed at the end of July: 40.8 °C in Lyubimets, Haskovo District and 39.6 °C in Ruse. On 31 July, daily anomalies of maximum temperature reached +10 °C and more in Dobrich, Veliko Tarnovo, Sliven, Stara Zagora and Kazanlak.

According to the 3-month Standardized Precipitation Index (SPI-3) values, a severe drought has occurred in the central part of South Bulgaria during the winter and from July to September in the country's central and eastern areas. The spatial distribution of two drought indexes for September 2020 is presented on Figure 4: SPI-3 on Figure 4a and SMI (Soil Moisture Index) on Figure 4b.

In 2020, prolonged periods without rain led to an agrometeorological drought that damaged crops. The winter drought from 14 December 2019 until 5 February 2020 had affected territories of about 19 700 km$^2$ in the regions of Plovdiv, Pazardzhik, Stara Zagora, Sliven, and Svishtov. During this period, the soil moisture reserved in the surface soil layer were below 60% of FC. The reduced soil moisture and abnormal temperatures caused yellowing in wintering cereals. Between 25 June to 3 September, another period of agrometeorological drought was registered. The regions of Veliko Tarnovo, Ruse, Varna, Shabla, Haskovo, and Kardzhali, were affected by this phenomenon (see Figure 4b). The summer drought caused damage, and reduced spring crop yields to about 19 000 km$^2$ of the country's agrarian territory.

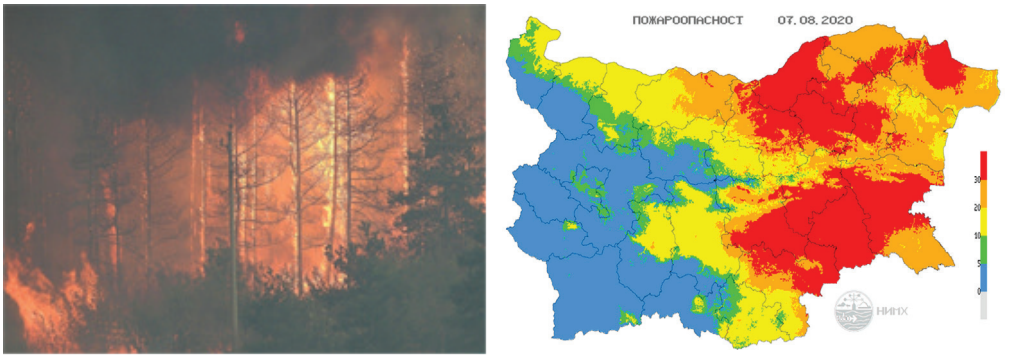



(a) (b)

**Fig. 4.** The spatial distribution of SPI-3 (a) and SMI (b) on the territory of the country for September 2020 (maps are from the archive of the NIMH operational information, presented on www.hydro.bg)

During the third decade of July, the high temperatures (39-40 °C) registered in some places in the eastern and southern regions of the country caused the dripping of flowers and knots of some late-grown vegetables such as cucumbers and zucchini. In some of the corn crops, there was wilting and drying of the leaves from the lower floors of the plants.

The prolonged rainless period in the eastern half of the country, combined with high temperatures and in some places with strong, gusty winds, increased the risk of fires, especially in the districts of Kardzhali, Haskovo and Yambol. In the period 8-11 August, a state of emergency was declared in five municipalities in the Haskovo region due to two large fires covering more than 100 km$^2$ of grass, bushes and agricultural lands. In the area of the Lesovo border checkpoint (Figure 5), the fire destroyed 11 km$^2$ of mixed forest. During the first two decades of September, the started in August rainless period continued in the eastern half of the country, which increased fire risk, especially in combination with high temperatures and wind gusts, in the districts of Kardzhali, Haskovo, Yambol and Stara Zagora.




(a) (b)

**Fig. 5.** (a) 8 August - the fire nearby Lesovo border checkpoint (b) 7 August – fire hazard index for the territory of the country (map is from the archive with operational materials of the NIMH)

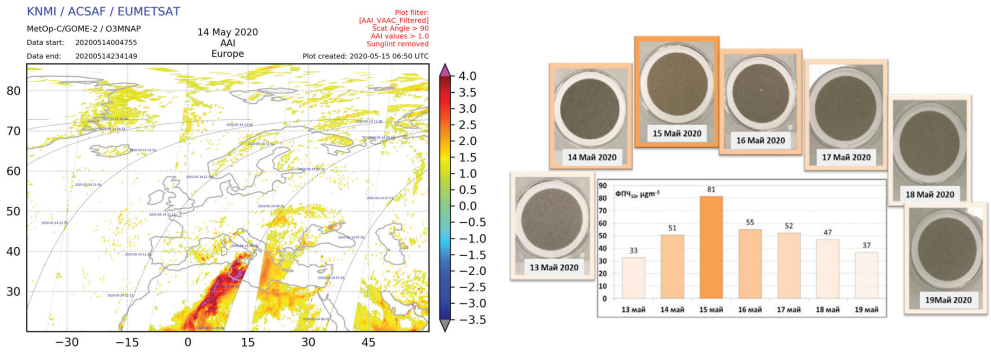
During the last week of December, the agrometeorological conditions were determined by unusually for the season warm weather. Climatic anomalies at the beginning of winter in Montana, Pleven, Veliko Tarnovo, Plovdiv, Pazardzhik and Chirpan, with maximum temperatures reaching 18-20 °C in some places, extended the vegetation of winter wheat. The high December temperatures provoked premature, undesirable swelling of the buds in some early flowering fruit species such as peach and cherry.

## 3.2. Intensive Saharan outbreak in May 2020

Extremely warm air mass advection from Northern Africa in the period 12-22 May brought Saharan dust aerosols towards the Balkans (see Figure 6 a). The peak was on 15 May when Foehn winds on the northern slopes of the mountains in Bulgaria were observed. In combination with the warm air mass advection, the temperatures in many regions of Bulgaria were above 30 °C (in Sevlievo, north of the Balkan Mountain,

37.7 °C). An extremely dry situation with a dusty atmosphere was observed in the next four days.

The visibility at peak Musala (2925 m) was reduced from 40 km on 14 May, 06:00 UTC, to 15 km at 18:00 UTC. The concentration of dust particiles $PM_{10}$ at the mountain peak Kopitoto (1345 m) near Sofia increased to a daily mean value of 104.7 $\mu gm^{-3}$ on 14 May. This is by a factor of 2 higher than the EU daily limit value (50$\mu gm^{-3}$) and by a factor of 15 higher than the mean $PM_{10}$ for the previous two weeks. The chemical analysis of $PM_{10}$ samples collected at NIMH on 15 and 16 May 2020 (Figure 6 b) showed high concentrations of the elements *Ca*, *Mg*, *Al* and *Fe*, with ratios *Ca/Al =2.24, Fe/Al=0.52, Mg/Al=2.42* suggesting the origin of the aerosol particles in northwestern Africa (Algeria and Tunisia) (Marconi et al., 2014).




(a) (b)

**Fig. 6.** Aerosol absorbing index AAI by GOME-2 on METOP-B satellite on 14 May 2020 (source www.*temis.nl*) (a); $PM_{10}$ daily concentrations and filters at NIMH-Sofia during 13-19 May 2020 (b)

## 3.3. Strong wind events and severe convective storms

Several wind storms were reported in 2020, especially during the winter months. During the period 29-30 January, strong to stormy west-northwest winds with speeds of 14-19 m/s and gusts up to 24 m/s were reported for different cities in the country. More significant damages were registered in the districts of Sofia, Sliven and Varna, such as uprooted trees, felled down fences and billboards, and others. The ports of Varna and Burgas also remained temporarily closed.

In the period 3-6 February, a rapid fall in temperature, combined with heavy snowfall and strong winds, caused serious traffic and power supply problems, mostly in North Bulgaria. The media also reported broken windows, fallen trees and damaged roofs, especially in the districts of Varna (see Figure 8, left) and Sofia.

On 15 May, strong wind, with gusts over 20 m/s, caused significant damage in many places in northern Bulgaria. In the early hours of the day, a hurricane-force wind blew

off the roof of the Military District in Vratsa and knocked it down on two neighboring houses and cars parked nearby. There are no reports of people affected by the disaster. Due to the strong wind, the cranes at the port of Ruse stopped working. The 850 hPa maps for 15 May are shown in Figure 7a and Figure 7b.

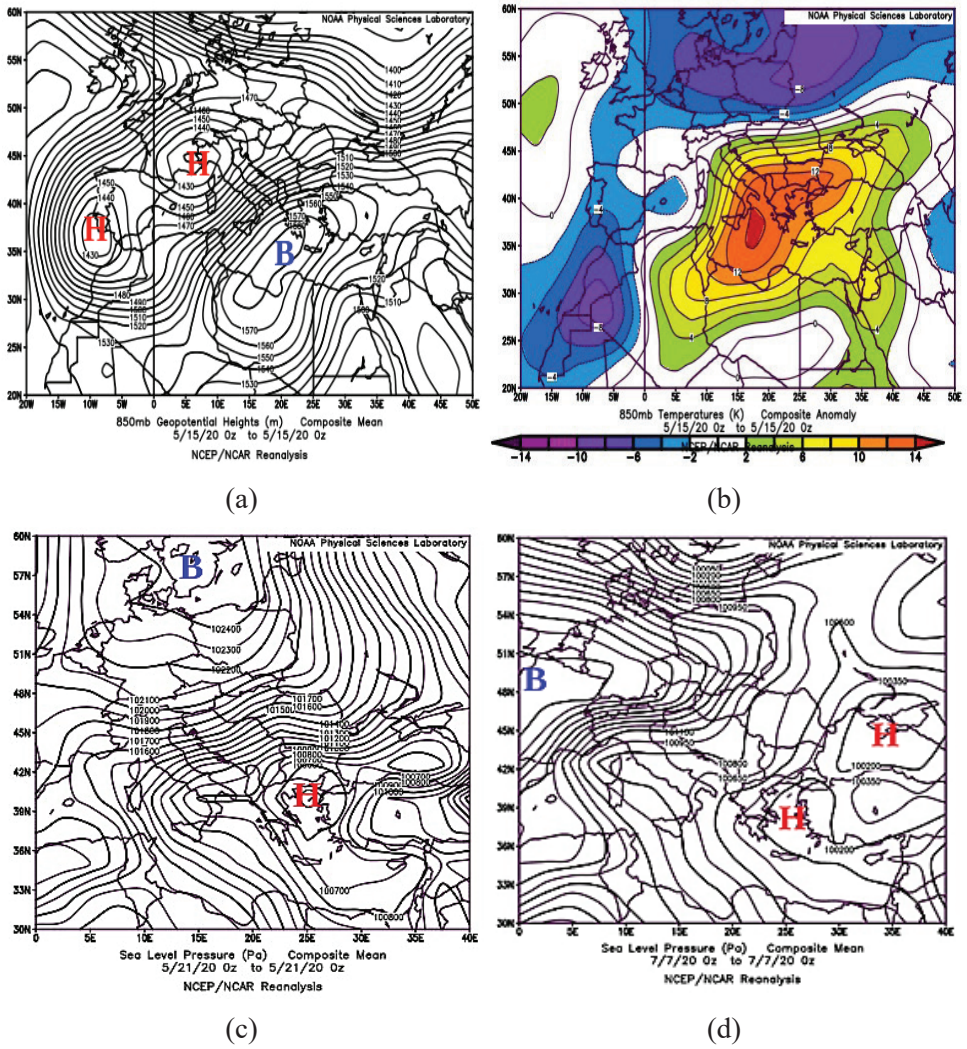



**Fig. 7.** Maps of: height (m) of the geopotential surface (a) and deviation of the temperature from the norm (K) (b) of 850 hPa on 15 May at 00:00 UTC; maps of the atmospheric pressure reduced to sea level (Pa) on 21 May (c) and 7 July (d) at 00:00 UTC. The maps are based on the atmospheric reanalysis of Kalnay et al. (1996) and are produced on the NOAA Physical Sciences Laboratory website, https://psl.noaa.gov/.

Strong wind, with gusts between 16 and 25 m/s, was registered on 14 December near the Black Sea coast and in some regions of the southern half of the country. The highest gusts, up to 34 m/s, were registered in the region of Sliven, where fallen trees and overturned cars were reported. On 28-29 December, strong (to hurricane-like) south winds knocked down trees, branches, construction fences and billboards, mainly in the southern parts of Sofia. The Sofia Municipality also reported fallen electric poles, broken traffic lights and temporary interruption of some public transport lines.

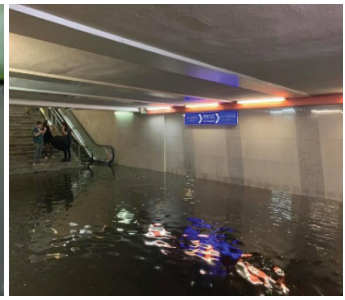
Severe thunderstorms, accompanied by torrential rains, hail and stormy winds, leading to local floods, road damage and broken electricity pools, were registered mainly in western and central parts of the country in May, June, July, and the first half of August.

On 20-21 May, thunderstorms with hail and heavy rainfall caused significant damage to many settlements, mainly in northwestern Bulgaria. Thunders caused several fires in the Vidin region. On the evening of 20 May, a large hailstorm the size of a chestnut, lasting over 10 minutes, caused damage in the districts of Sofia, Vidin and Montana. An egg-sized hail fell in Godech municipality on 21 May (Figure 8, middle). It was accompanied by strong wind and rain and caused great material damages – broken windows of houses and cars, destroyed roofs and damaged agricultural areas. The sea level pressure field over Europe on 21 May, 00:00 UTC is presented in Figure 7c.

On 14-15 June, a powerful thunderstorm, accompanied by intense rain and hail, led to damages in many parts of the country. More than 30 houses in the village of Kazichene, Sofia District, were flooded. As a result of the heavy rains, dozens of flooded houses and significant damages to the Veliko Tarnovo District's road infrastructure were reported. Due to the huge amount of water poured into the region, the road that connects the city with several other neighboring villages was destroyed by a landslide.

**6 February** – After a windstorm in Varna (chernomore.bg)

**21 May** – Hailstones in Godech (Facebook: P. Ivanov)



**6 July** – Flooded metro station in Sofia (Facebook: I. Temelkov)

**Fig. 8.** Severe storms damages in different months

On 6 July, at night hours, a severe thunderstorm, accompanied by torrential rain, hail, and strong wind, caused serious damages in various regions of Sofia. The sea level pressure field over Europe on 7 July, 00:00 UTC is presented in Figure 7d. The

disaster lasted about 2 hours. Precipitation amounts measured in some stations in the southwestern part of the capital exceeded 50 l/m$^2$. Subway and some subway stations (Figure 8, right), shops, streets, ground floors of administrative and residential buildings were flooded. The Vladayska, Slatinska and Perlovska rivers overflowed. Bul. "Evlogi and Hristo Georgievi" became a canal, and the wave dragged a dozen cars. The strong wind fell down nearly 70 trees.

Heavy rains, thunderstorms and hail hit significant parts of Northwestern Bulgaria on 25 July. The storm caused floods in many parts of Sofia. There were flooded streets, residential and administrative buildings also in Montana, Vratsa, Varshets, Krivodol and others. Damages to road infrastructure had been caused.

## 5. CONCLUDING REMARKS

This article is aimed at a wide range of readers interested in the meteorological features of 2020 in Bulgaria. Analyzes show that this is the second warmest year, after 2019, for the entire 91-year period since 1930. Annual precipitation is around and slightly below normal. The number of extreme weather events in 2020 is moderately high. They were observed in all seasons. There were cases of snowstorms and strong wind in winter; cold spells in April, followed by unusually warm weather and a Saharan dust outbreak in May; during the summer, severe convective storms led to local floods and other damages, mainly in western and central parts of the country; at the same time East Bulgaria suffered from prolonged drought, which in late summer and autumn led to forest fires, mainly in southeastern regions.

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