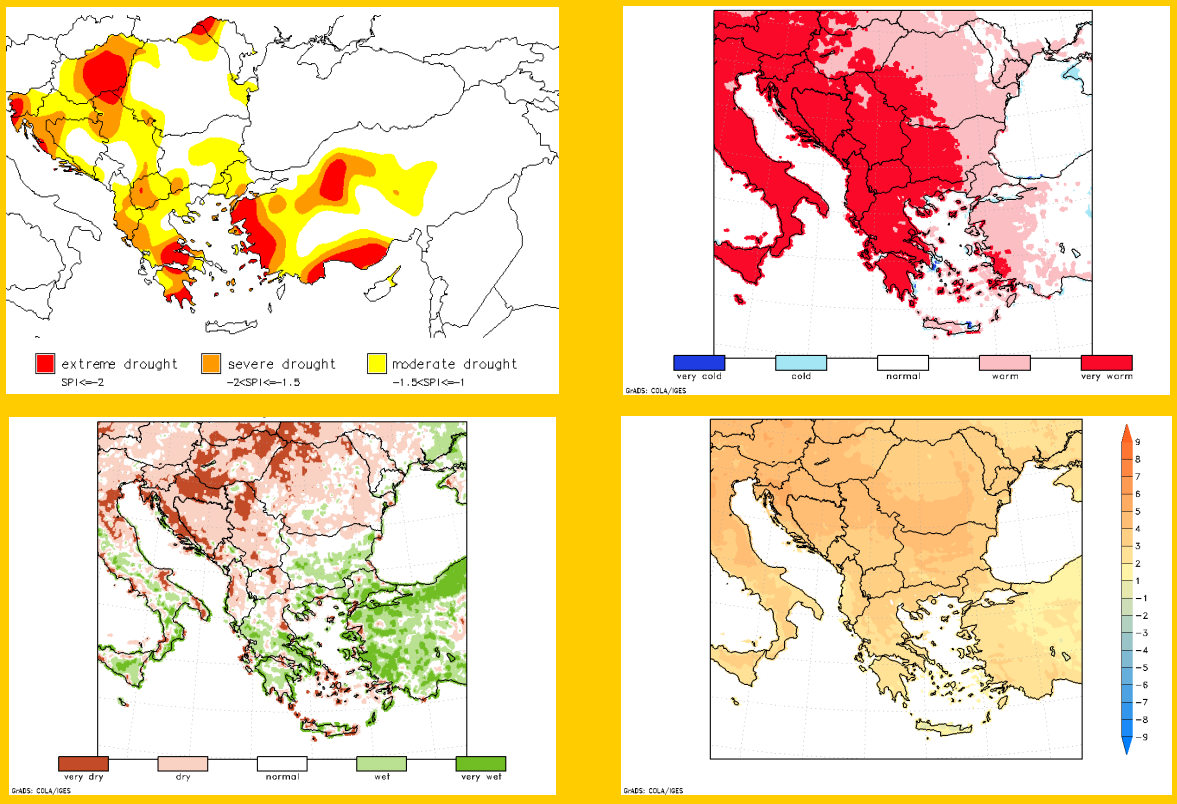
DROUGHT MONITORING BULLETIN

Overview from January to December 2022

HOT SPOT



***SPI3 for May** 2022 (top left), 60-day **mean air temperature 11 May-9 July** 2022 in percentile classes (top right), 60-day **accumulated surface water balance 10 June-8 August** 2022 in percentile classes (bottom left), and 60-day **mean air temperature anomalies 28 September-26 November** 2022 (bottom right)*

In southeastern Europe, year 2022 proved itself as one of a kind, with a continuous run of alternating – or sometimes cocurrent – very dry and very warm spells lasting for weeks to months throughout all four seasons. In short and being more pronounced over the Balkan Peninsula, it can be described as beginning with dry winter, continuing into dry spring, bringing also warm and dry summer and concluding with warm autumn, with only occasional spells in between that brought relief to dryness and heat. Especially devastating for agriculture and hydrology sectors and ecosystems were dry winter and spring with considerable length of rainless weather, and extreme summer heat accompanied with lengthier rainless periods. Figures above focus on most prominent precipitation and air temperature conditions throughout the vegetation season 2022: in top left, SPI3 shows the geographical extent and severity of lack of rain during the March to May period; in top right, mean air temperature between mid-May and mid-July classified as one of the hottest early summers in much of the western half of Balkan Peninsula; in bottom left, mid-June to mid-August accumulated surface water balance shows severity and extent of its deficit, coming after already dry spring; in bottom right, mean air temperature of the October-November period exceeded the average for 4-6 °C, among the warmest in last 30 years across the entire region.

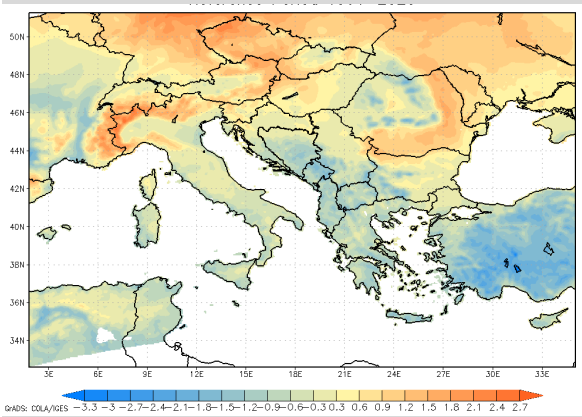
AIR TEMPERATURES AND SURFACE WATER BALANCE

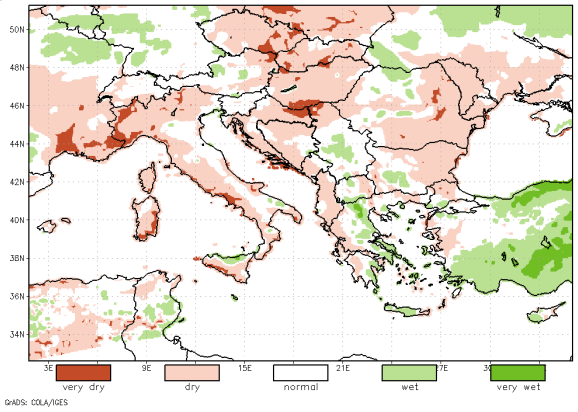
Figures in this section present deviations from the average of the 1991-2020 period of monthly ***air temperature (anomalies)*** *and monthly accumulated* ***surface water balance (percentile classes)*** *from* ***January to December 2022****.*

AVERAGE AIR TEMPERATURE ANOMALY [°C]

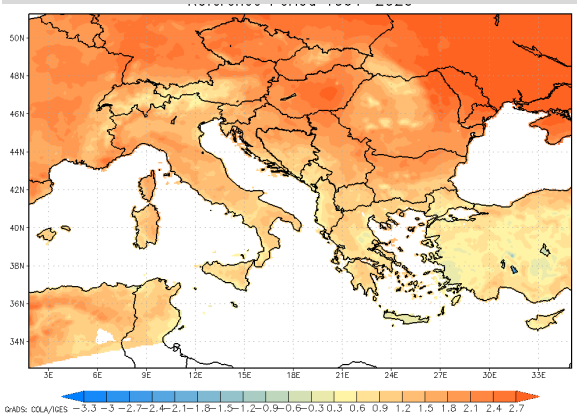
SURFACE WATER BALANCE ANOMALY [percentile classes]

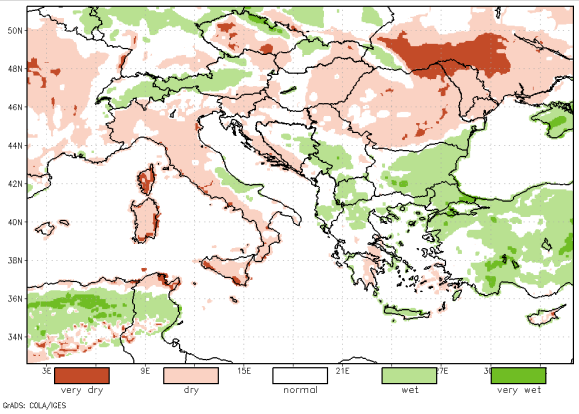
JANUARY 2022





FEBRUARY 2022





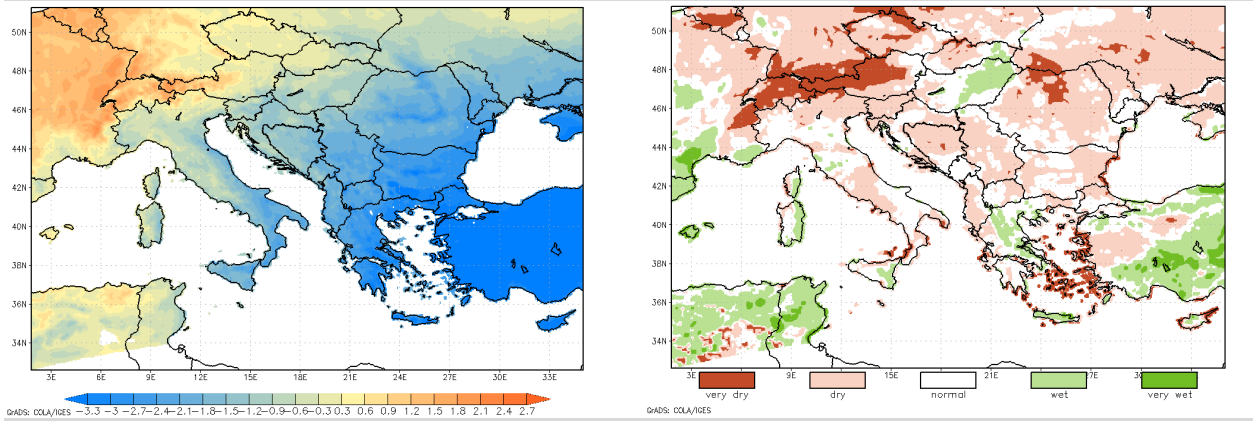
January was on average 1.5-2 °C colder than normal across most parts of the region while in Slovenia, western Hungary, southern and eastern Romania and over Moldova January was 1-2 °C warmer than usual. Most parts of the region also experienced precipitation deficit, most noticeably over western half of Balkan Peninsula and over its eastern part including Moldova, most of Romania and eastern half of Bulgaria. First month of the year ended with accumulated surface water balance deficit of mostly up to 60 mm in those areas, up to 100 mm over western Greece and up to 160 mm over the southern Adriatic Sea. Noticeable surplus was present only over Turkey and Aegean Greece.

Precipitation deficit continued in **February** across the northern half of Balkan Peninsula and central Greece, resulting in additional accumulated surface water balance deficit of 40-80 mm, in southern Adriatic Sea up to 120 mm. At the same time, the entire region experienced unusually warm air temperature for this time of year. Monthly mean stood up to 1.5 °C above the average over Turkey and southern half of Balkan Peninsula, while across its northern areas February mean air temperature exceeded the average for between 1.5 and 3 °C, with highest anomalies present over Hungary and Moldova.

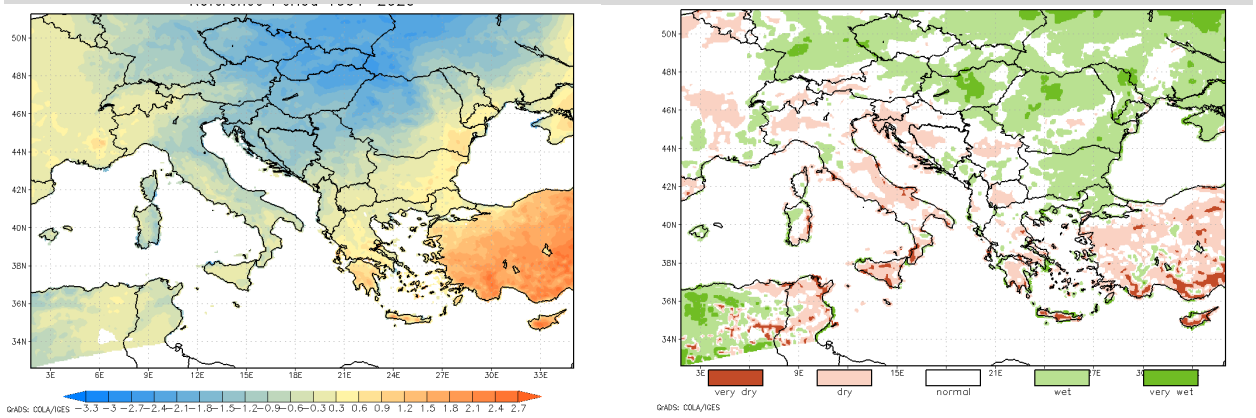
AVERAGE AIR TEMPERATURE ANOMALY [°C]

SURFACE WATER BALANCE ANOMALY [percentile classes]

MARCH 2022



APRIL 2022

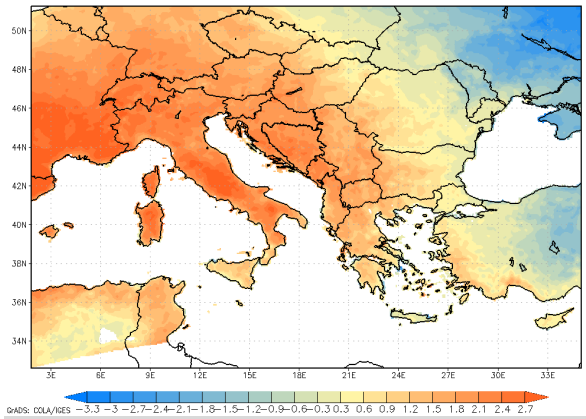


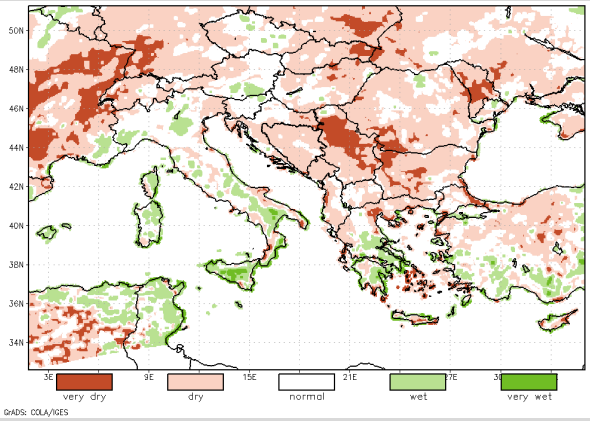
Very cold weather came into the region in **March**, with anomalies from the long-term average increasing towards south-east. In northwestern quarter of Balkan Peninsula, March was up to 1.5 °C colder than normal, in a belt from Moldova to Albania up to 2.5 °C colder while over most of Greece and all of Turkey monthly mean stood more than 3 °C below the average, among the coldest March air temperatures in local records. At the same time, it was very dry across most of the region, only over central-eastern Greece and greater central Turkey March was also wet. Monthly surface water balance in that part of the region accumulated in surplus of mainly 80-100 mm, while most of the Balkan Peninsula and parts of western Turkey experienced deficit of up to 60 mm, over Slovenia, Bosnia and Herzegovina, Albania and northern Romania up to 100 mm. For a vast part of northern half of Balkan Peninsula, this was a third month in a row experiencing under-average precipitation amount and consequently surface water balance deficit.
Over most of the northern half of Balkan Peninsula, colder than normal air temperatures continued in **April**. Monthly mean stood 1-2 °C below the April average in area from Moldova to Bosnia and Herzegovina and Slovenia, in eastern Hungary up to 2.5 °C lower than normal. On the other hand, southern Greece and Turkey saw sudden increase in air temperature, going from about 3 °C colder than normal March to up to 2°C warmer than normal April, in southern Turkey up to 2.5 °C warmer. At the same time, it was a dry month over this part of the region, bringing monthly surface water balance deficit of up to 60 mm, in southern Turkey up to 80 mm. Precipitation level was lower than expected also in northwestern and central Balkan Peninsula, from Slovenia to North Macedonia, resulting in monthly surface water balance deficit of 20-60 mm. Especially northern and eastern part of Balkan Peninsula recorded higher than normal precipitation level, resulting in surplus of monthly surface water balance of up to 60 mm, locally up to 100 mm.

AVERAGE AIR TEMPERATURE ANOMALY [°C]

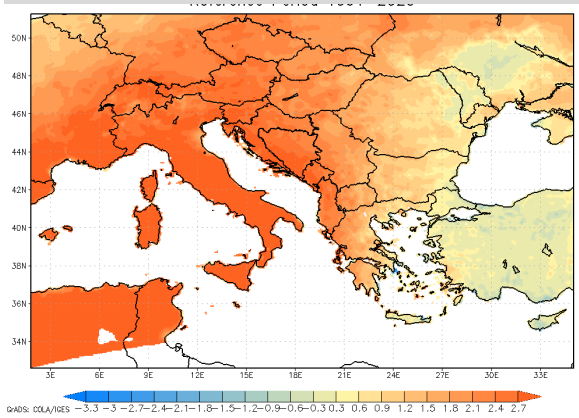
SURFACE WATER BALANCE ANOMALY [percentile classes]

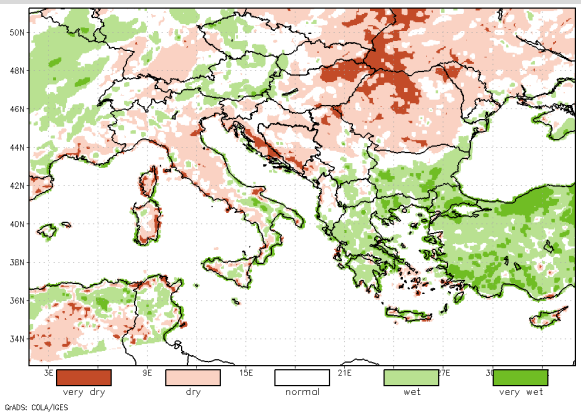
MAY 2022





JUNE 2022





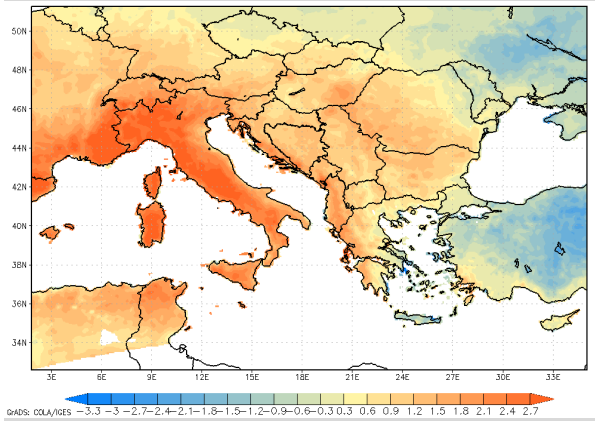
For most of the Balkan Peninsula, summer weather conditions began in **May** already as much higher than normal air temperatures spread across the entire western and central third of the peninsula. Monthly mean exceeded the May average for up to 2 °C, in wider area along the Adriatic Sea up to 3 °C. Turkey experienced another month of sudden change in air temperatures, after a warm April it was again 1-2 °C colder than normal for this time of year. Up to 1.5 °C colder than normal was May also over Moldova. With May came drier than normal spell of weather again over much of the region, most noticeably over Balkan Peninsula where much of the area recorded monthly surface water balance deficit of up to 80 mm, over much of Greece and Turkey between 40 and 60 mm.

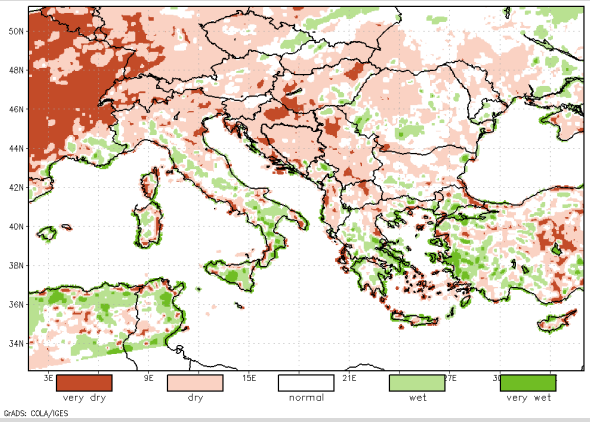
Warmer than normal air temperatures over Balkan Peninsula continued throughout **June** as anomalies from the average even intensified. Along the Adriatic Sea from Slovenia to Albania, June was 3 °C warmer than normal, one of the hottest in local records, and over much of the central belt from Hungary over Romania to continental Greece June was 1.5-2.5 °C warmer than normal. In terms of precipitation conditions, the region was clearly divided north-to-south, with areas north of the belt from Montenegro to southern Romania ending a month with another surface water balance deficit of 60-80 mm, over Moldova and northern Romania up to 120 mm, one of the driest levels in local records for this time of year. Bulgaria, southern Serbia and other areas in the south of the region recorded high precipitation levels, locally resulting in one of the wettest June conditions of local records. June surface water balance was over most of this part of the region in surplus values of up to 60 mm while locally in Bulgaria, Greece and southern Turkey monthly surplus reached up to 100 mm, in northern Turkey up to 180 mm.

AVERAGE AIR TEMPERATURE ANOMALY [°C]

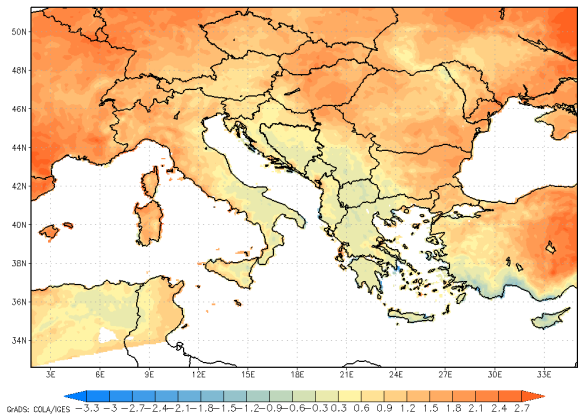
SURFACE WATER BALANCE ANOMALY [percentile classes]

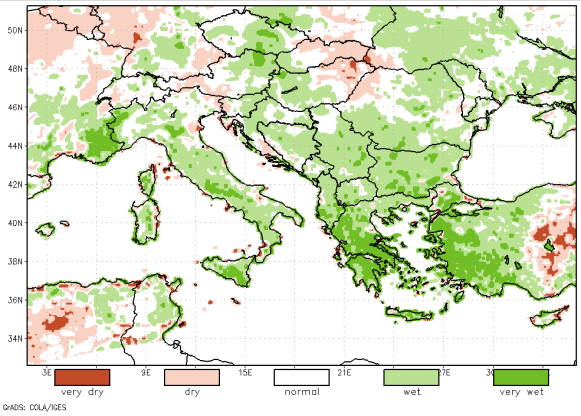
JULY 2022





AUGUST 2022





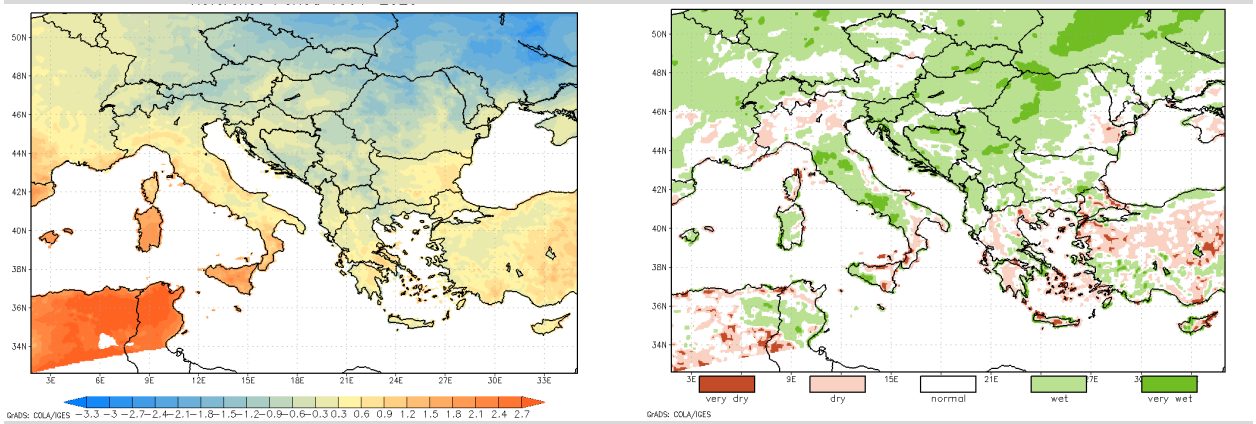
Similar air temperature conditions as in June continued into **July**. Most of the Balkan Peninsula continued to experience warmer than normal air temperatures, where monthly mean air temperatures were 1-2 °C above the long-term average, along the Adriatic Sea up to 2.5 °C, while over Moldova and Turkey July air temperatures were on average 1-2 °C colder than normal, over central Turkey up to 2.5 °C colder. On the other hand, precipitation deficit prevailed across most of the region, with the exception of some scattered, localised areas, Aegean Greece and northern Turkey. Vast part of Balkan Peninsula, especially areas with dry weather coupled with unusually high air temperatures, recorded another month of accumulated surface water balance deficit, mostly between 40-80 mm.

In **August**, air temperatures normalised over southwestern half of the region from Croatia to Aegean Greece but rose up to 2 °C above the August average over the rest of the region, in central Turkey up to 2.5 °C. Despite August being warmer than normal in many parts of the region, it was also wet across vast part of it, except for western Slovenia, most of the Pannonian Basin and central Turkey. It brought considerable precipitation level, which over Greece and western Turkey classified among the wettest 5 % of local August records. Monthly surface water balance was in the latter parts of the region up to 180 mm higher than normal, locally even more than 200 mm, in northern Romania up to 140 mm higher than normal while elsewhere across central Balkan Peninsula it exceeded the average for mostly 40-80 mm. For great part of Balkan Peninsula's northern half, August was the first month since April bringing favourable precipitation conditions, but which was not the case for western Slovenia and the Pannonian Basin across eastern Hungary and western Romania, as they continued to experience surface water balance deficit, with August levels 40-60 mm lower than the monthly average.

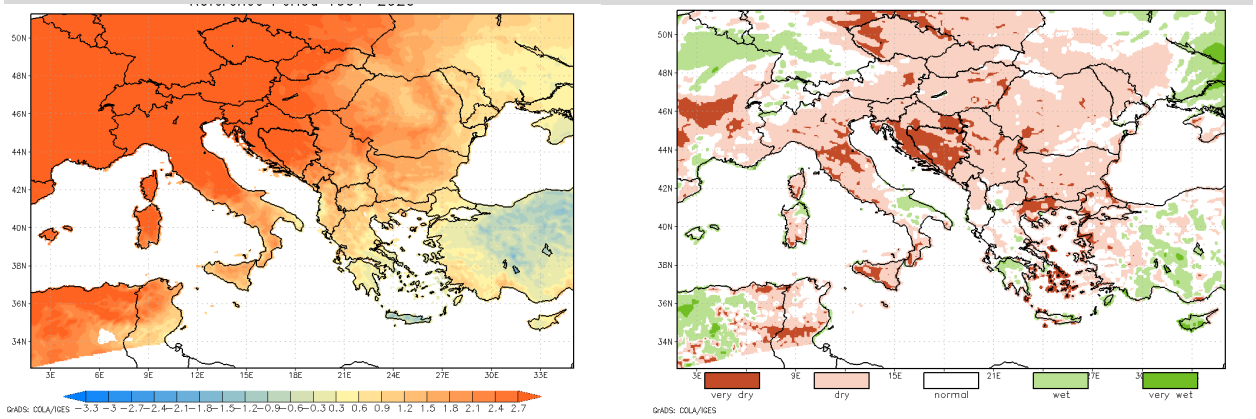
AVERAGE AIR TEMPERATURE ANOMALY [°C]

SURFACE WATER BALANCE ANOMALY [percentile classes]

SEPTEMBER 2022



OCTOBER 2022



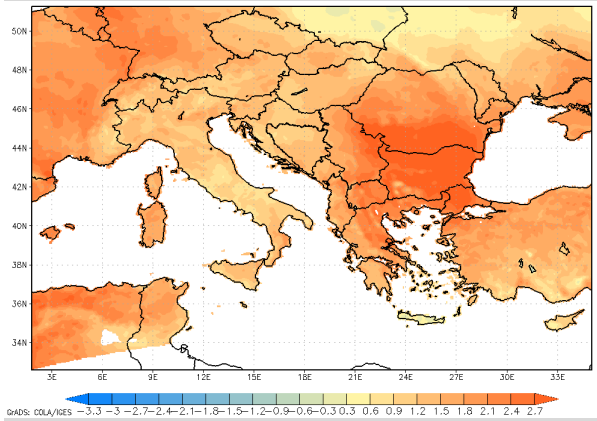
With **September** came colder and wetter than normal weather conditions to most of Balkan Peninsula, and slightly warmer than normal and dry weather conditions to Greece and Turkey. In countries of the region as far south as Albania and North Macedonia, September was up to 1.5 °C colder than normal, in northern Romania up to 2 °C colder, bringing also high precipitation amount which contributed to well above-average monthly surface water balance – surplus in many parts of northwestern half of Balkan Peninsula from Albania to northern Romania ranged between 80 and 100 mm, along the Adriatic Sea up to 140 mm and over the western and northern Romania up to 200 mm. Two consecutive months of considerable surface water balance surplus over this part of the region brought lasting drought conditions to an end. Over Aegean Greece, eastern Bulgaria and Turkey, September air temperatures ranged about the average and precipitation level was only slightly less than normal, resulting in up to 40 mm of monthly surface water balance deficit.

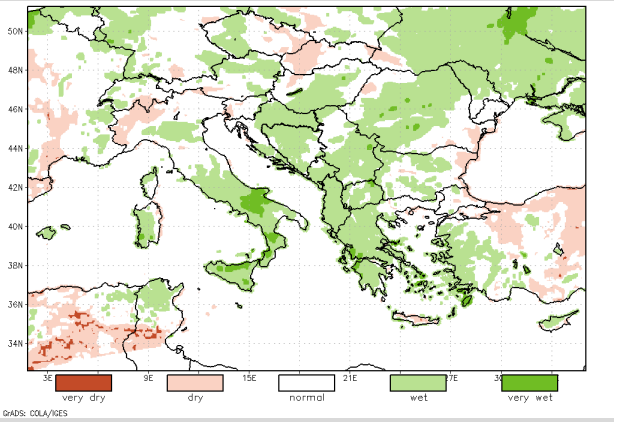
October saw sudden shift in weather conditions across most of the Balkan Peninsula, bringing well warmer than normal air temperatures as well as considerable lack of rain. While October mean air temperature over Moldova, Greece, Albania and North Macedonia was up to 1.5 °C higher than the long-term average, it exceeded the average for up to 2.5 °C over central and eastern Balkan Peninsula and for more than 3 °C over its northwestern quarter and regularly exceeding 20 °C, making October one of the hottest of the record in this part of the region. Dry month resulted in noticeable monthly deficit in surface water balance, 60-80 mm across most part of Balkan Peninsula and Aegean Turkey, and between 120-180 mm along the Adriatic Sea.

AVERAGE AIR TEMPERATURE ANOMALY [°C]

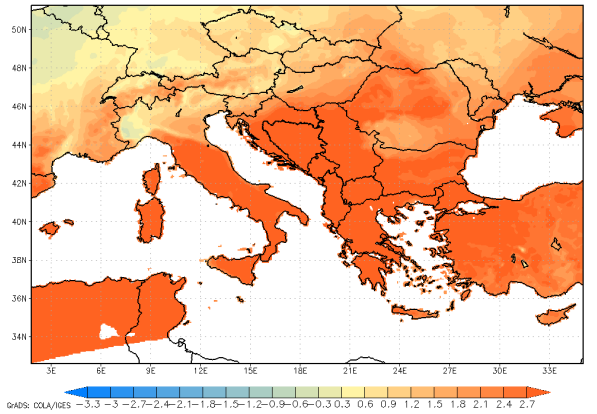
SURFACE WATER BALANCE ANOMALY [percentile classes]

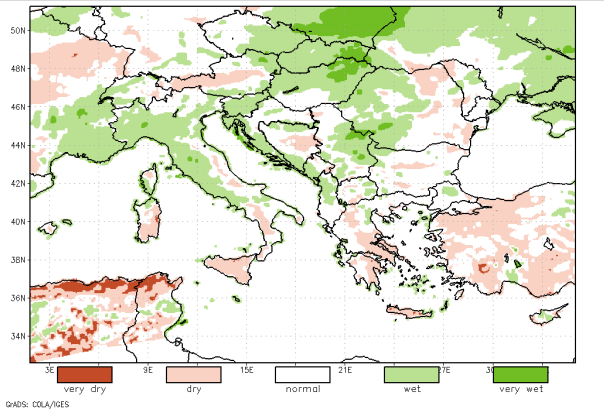
NOVEMBER 2022





DECEMBER 2022





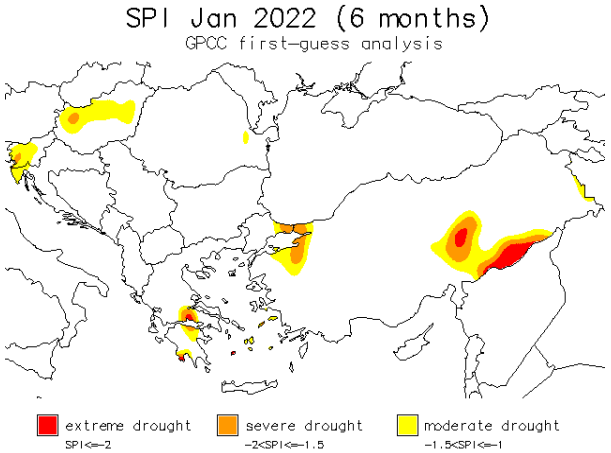
Unusually warm air temperatures for this time of year continued in **November**. Monthly average was exceeded by at least 2 °C over Romania, Serbia, North Macedonia and northeastern Greece, over Bulgaria by more than 3 °C. Even over other parts of the region November mean was at least 1.5 °C above the long-term average. November was a wet month over most of Balkan Peninsula, but with unusually warm air temperatures monthly surface water balance still ranged about the normal levels. Noticeable monthly surplus was detected only over its southwestern and central parts: up to 60 mm over southern Adriatic Sea and southwestern Romania, up to 120 mm over Albania while locally in central Greece and southern Montenegro surplus of about 200 mm was present. However, there was less precipitation than normal over central Turkey and the region's northwestern-most part, where monthly surface water balance resulted in a deficit of up to 60 mm over central Turkey and up to 100 mm over western Slovenia.

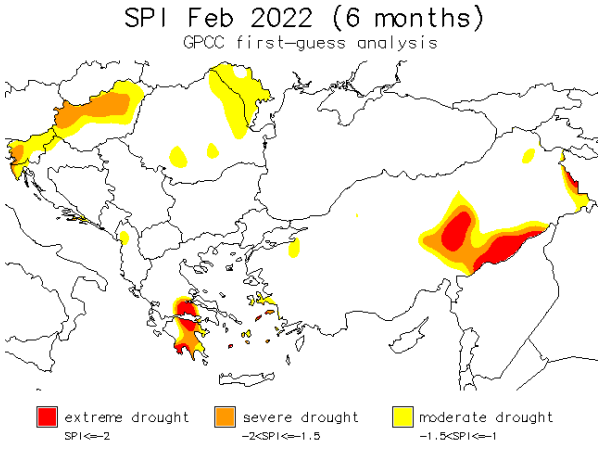
Warmer than normal weather lasted into **December** as well, as on monthly average it was at least 2 °C warmer than expected, especially over a wider central-western and Aegean Sea area where monthly mean exceeded the long-term average for about 3 °C. Daily air temperatures regularly stretched up to 15 °C across the region, making December one of the warmest of the record. It was also a dry month over Turkey, Greece and Bulgaria and over parts of Romania, North Macedonia and central Bosnia and Herzegovina, ending with a monthly deficit in surface water balance of up to 60 mm, over central-eastern Greece and coastal Turkey 80-120 mm. Over the region's northern and central part as well as along the Adriatic Sea coastline, December ended with a monthly surface water balance surplus of 40-80 mm, locally in southwestern Romania and along the Adriatic Sea up to 120 mm.

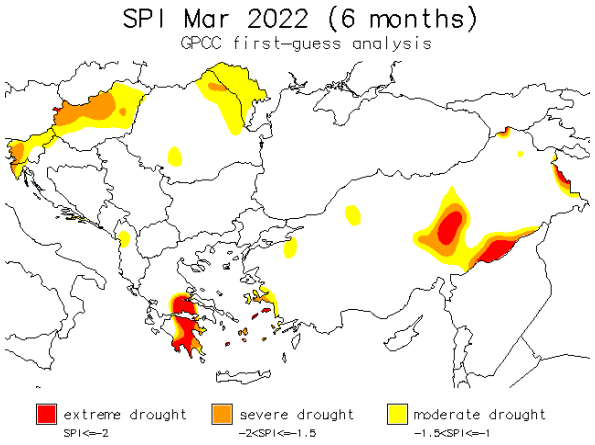
STANDARDIZED PRECIPITATION INDEX

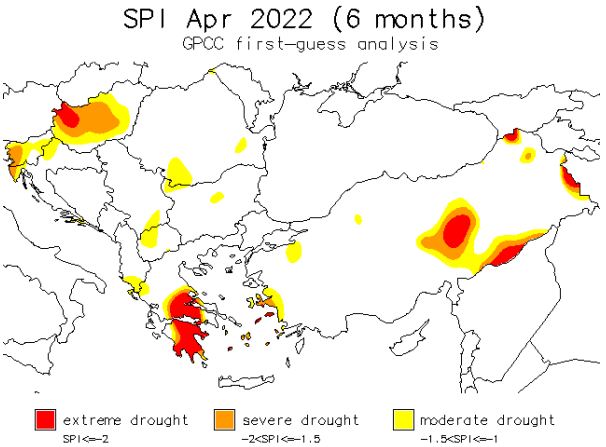
Drought situation with regard to precipitation accumulation is presented by Standardized Precipitation Index (SPI). The SPI calculation is based on distribution of precipitation over long–time period (in our case long–term average 1961–1990 was used). SPI can be calculated at various time scales which reflect impact of drought on availability of water resources. The long–term precipitation record is fit to probability distribution which is then normalised so that the mean SPI for any place and time period is zero. SPI values above zero indicate wetter periods while values below zero indicate drier periods than normal. Only the dry part of the extreme anomalies is presented on the maps below.

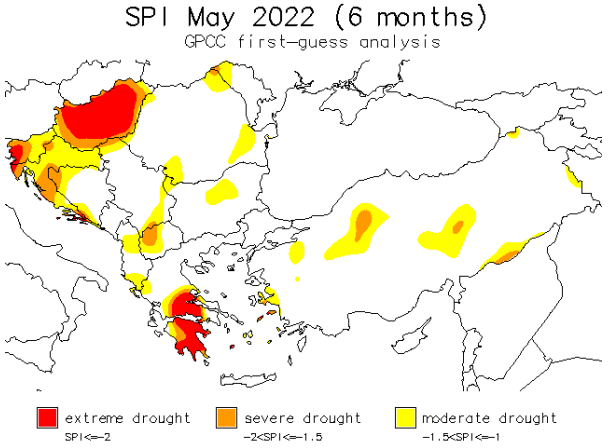
SPI maps for one and three months throughout 2022, which can be used for indication of meteorological and agricultural drought respectively, have already been published in individual monthly bulletins. Maps below show SPI for 6 months, which give indications about hydrological conditions throughout the year.

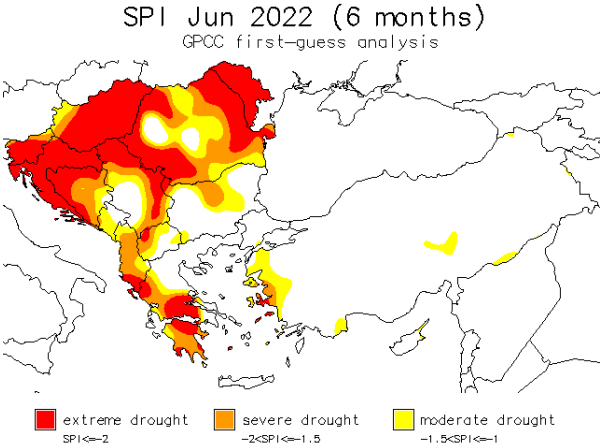


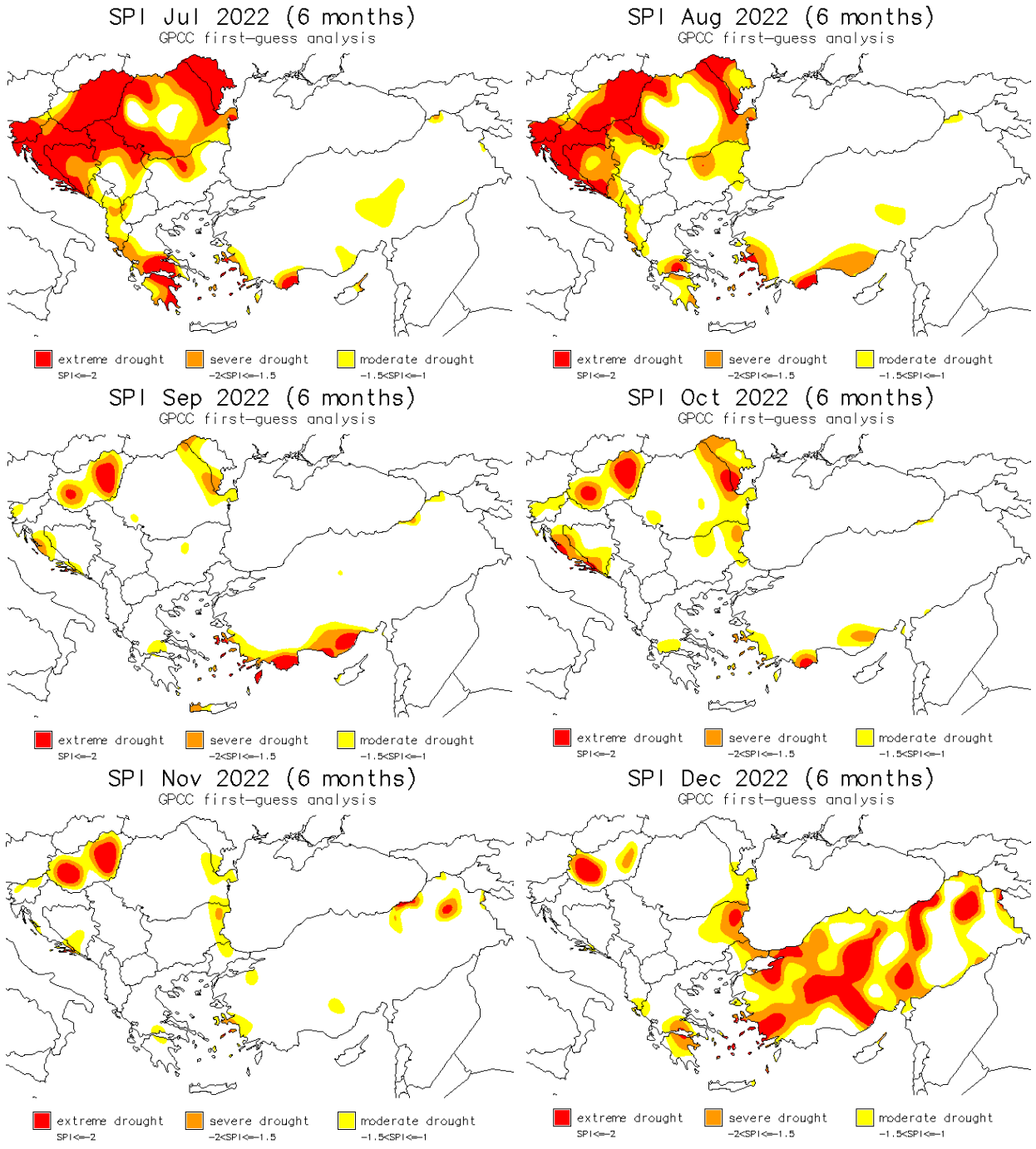












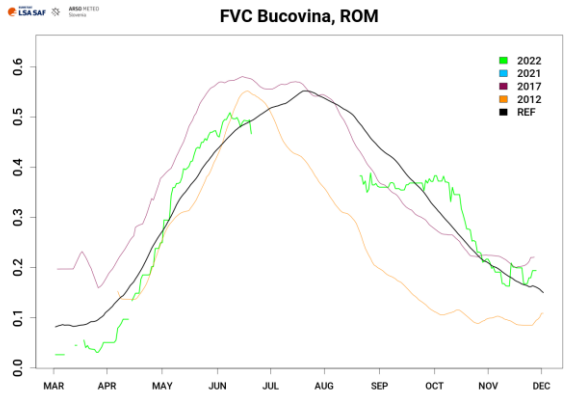
During the **winter** months 2022, much of the far northern belt of the region as well as parts of southern Turkey and southern Greece were experiencing moderate to severe drought conditions in hydrological sense, after autumn months in 2021 as well as following January and February – a period in a year which normally refills water reserves – all brought less precipitation than normal. From this point onward, hydrological drought conditions only intensified across the region for much of the year. In **spring**, lack of rain was severe to extreme in March and May across nearly the entire Balkan Peninsula and western Turkey, and over wider central and southern Turkey in April. In such precipitation conditions of spring, hydrological drought conditions quickly intensified to severe and extreme levels over the region's north-west, especially Hungary, Slovenia and Croatia, and over southern Greece before the end of spring. Precipitation level during **summer** months was highly variable across the region, with extreme lack of rain in June over the entire

northern half of Balkan Peninsula, moderate to severe lack of precipitations in July over parts of northern and eastern Balkan Peninsula and severe over northeastern Turkey, and with August precipitation levels considerably lower than normal only over the region's north-west and Turkey's north-east. Despite some precipitation amount received during summer months in those parts of the region, or not experiencing heavy deficit in others, it was the continuous run of months with less than sufficient precipitation level since the beginning of the year that saw great intensification of hydrological drought to extreme levels across nearly the entire Balkan Peninsula from spring to early summer. Such extreme hydrological drought conditions lasted throughout July also and began decreasing only in August, when intensity of hydrological drought returned from extreme to moderate or even ceased completely over parts of southern and central Balkan Peninsula. Despite August and September bringing decent precipitation levels again to much of the region, SPI6 during **autumn** months reveal some areas still suffered moderate to severe lack of rain over the past 6-month period, which maintained hydrological drought of moderate to severe level across western, northern and eastern belts of Balkan Peninsula and scattered localised areas elsewhere, and to extreme level over Hungary. Intensity of the hydrological drought continued to decrease over much of the region until the end of autumn but intensified again at the **end of the year**, mostly on the account of again much drier than normal October over vast part of Balkan Peninsula and western Turkey, and extremely dry December over all Turkey and southern Greece.

REMOTE SENSING – FRACTION OF VEGETATION COVER

Fraction of vegetation cover (FVC) is a vegetation index, based on multi–channel remote sensing measurements (data from Eumetsat's LSA SAF database is used for products in this bulletin). FVC shows fraction of the total pixel area that is covered by green vegetation, which is relevant for applications in agriculture, forestry, environmental management and land use. Values vary according to the vegetation stage and of course to the damages of possible natural disasters (including drought). FVC values are lower at the beginning of the growth season, the highest at the full vegetation development, then FVC slowly drops with vegetation senescence. Line shape depends on sort of the vegetation. Index deviation from the long-term average (reference line) has proved useful for drought monitoring.

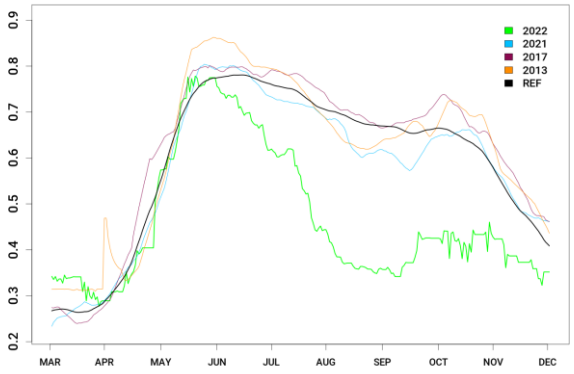
Graphs below present **vegetation development** from **March to December 2022** at 13 locations across southeastern Europe, as indicated by FVC index. FVC values for year 2022 are presented as green line. Graphs also include reference line (2004–2021) in black, and lines in light blue (year 2021), magenta (year 2017, or 2013 for Slovenia) and orange (year 2012) for comparison. Possible missing values or sharp decline of values could be a result of a prolonged cloudy weather, extreme weather events, snow blanket or changes to product by product provider.



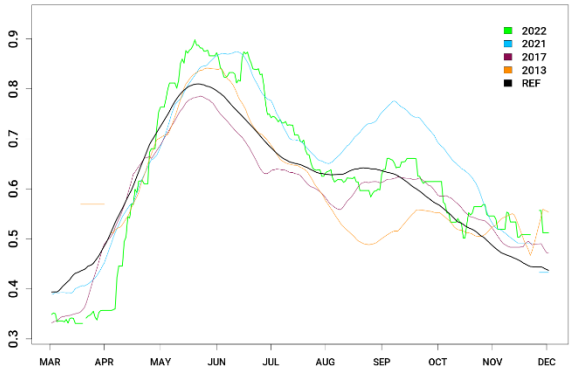
Graphs of FVC at the following locations (from top left to bottom right):

Romania – Bucovina;
Slovenia – Murska Sobota, Nova Gorica;
Serbia – Malo Orasje, Veliko Srediste;
Bosnia and Herzegovina – Laktasi, Bijeljina, Trebinje;
Montenegro – Podgorica;
North Macedonia – Lozovo, Kavadarci;
Greece – Larisa, Kalamata.

FVC Nova Gorica, SVN



FVC Murska Sobota, SVN



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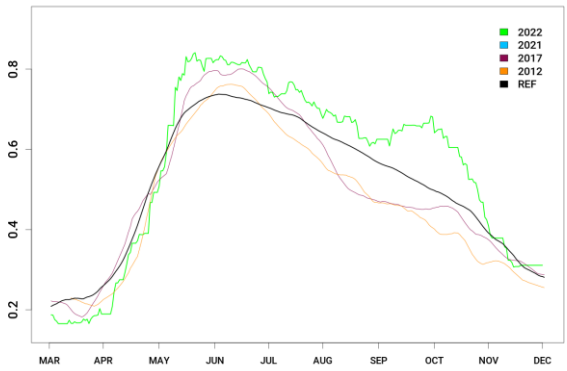

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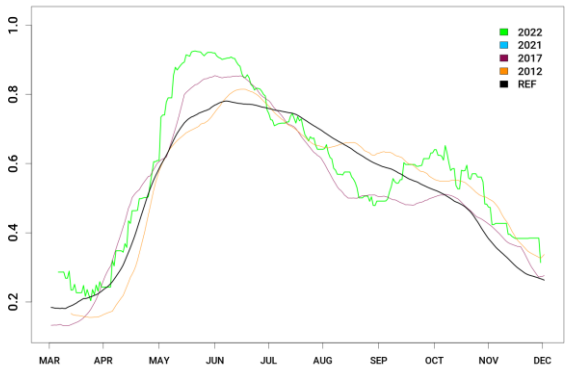

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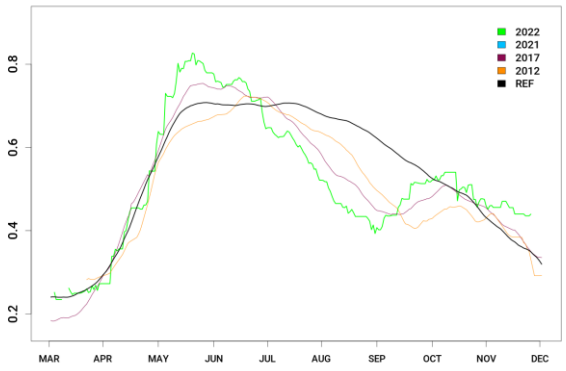

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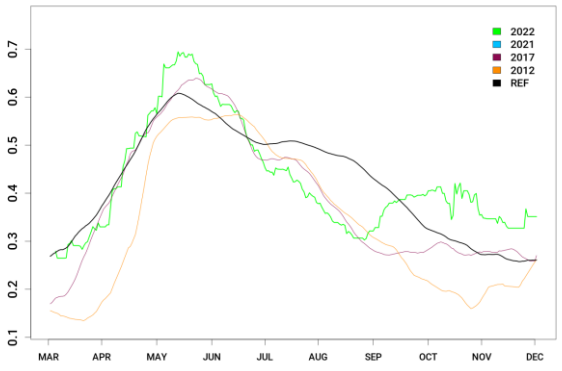

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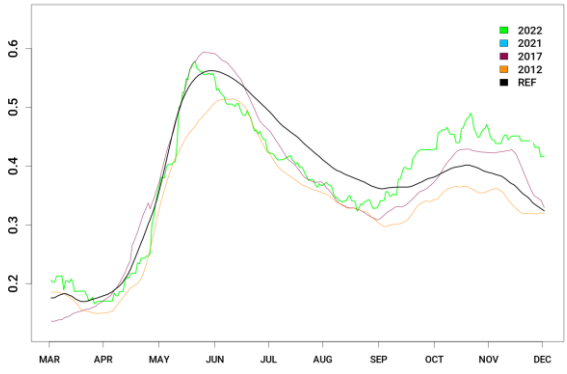

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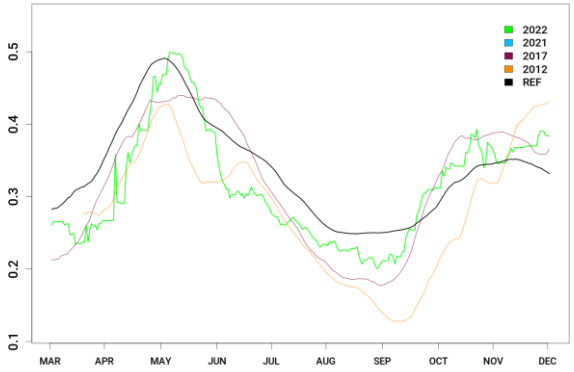

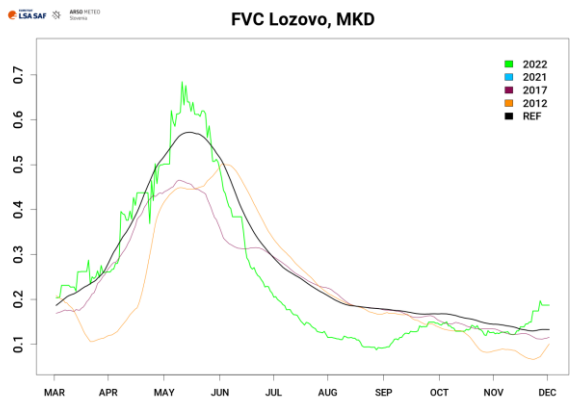

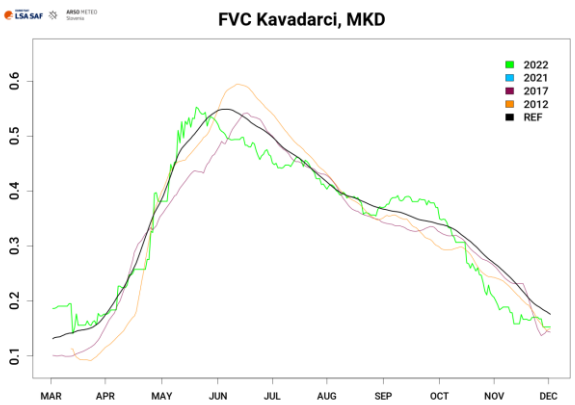

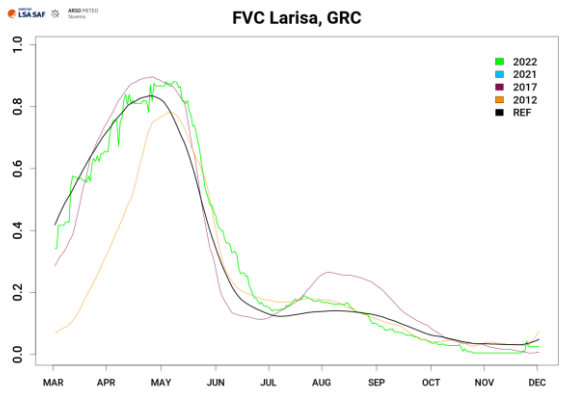

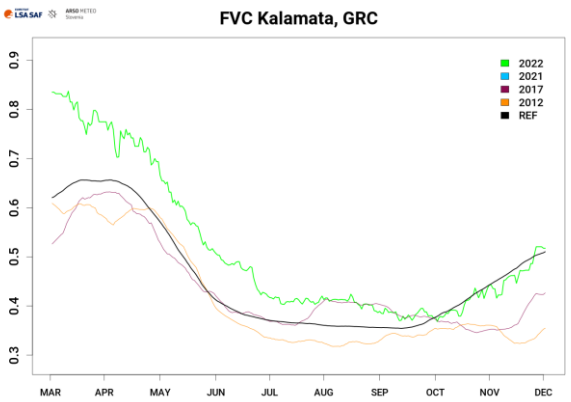

IMPACT REPORTS

HUNGARY

Year 2022 brought a historic drought to Hungary, the long-lasting lack of precipitation and heat stress caused enormous damage to plant growers, livestock breeders and the domestic food industry [1]. Hardly any precipitation fell in the first three months of 2022, as a result of which drought developed in a large part of the country already at the beginning of the vegetation period. By mid-summer, the plants suffered from the intensifying drought since mid-May, and without irrigation many summer crops already suffered irreversible damage. Three months passed with considerable lack of rain this summer, which practically destroyed the entire spring crop, especially **corn and sunflower**. Underdeveloped, low in height, withered from the bottom, scorched, tubeless boards with dried leaves were typical, and at many locations no harvest took place [2]. Much less corn than average was harvested from the fields, due to which the crop had to be **imported** to meet domestic needs [1]. A significant part of the second sowings of **sweet corn** did not succeed due to extremely dry spring and summer, so a decline in the sweet corn production area, together with the missed second sowings, was about 15 %. The amount of raw material that can be processed was further reduced by the extreme summer drought, so the national average of sweet corn loss was 35 %, while at some areas specifically the situation was worse, for example in the northern Great Plain, where the proportion of irrigated area is lower. Similarly, the **green pea** production was also decreased by 15-20 % compared to the average of previous years [3].

This year, it was not frost but drought that caused outstanding damage to the fruit sector. Based on the data of the Hungarian Vegetable and Fruit Association and Product Council, only about

300 000 tons of **apples** were harvested this year compared to the last year's 520 000 tons, which is approximately 42 % less [4]. Due to summer drought, **beekeepers** were able to produce half of the usual amount of honey, mainly east of the Danube, according to the president of the Bekes County Bee Association. Rapeseed and acacia only barely produced enough yield, but the oil radishes, lindens and sunflowers, which are the most typical in Bekes County, southeastern Hungary, did not produce almost any honey due to drought [5]. Although there were no exact data on this year's crop yet, producers in the Kunsag **wine** region, central-southern Hungary were able to harvest fewer grapes than last year, which was already lower than average due to drought, although the loss this year was smaller than previously expected. However, there were areas with practically no harvest, and some plantations were completely destroyed [6]. The prolonged drought caused unprecedented damage to **fish** ponds across the country. According to the Institute of Agrarian Economics data, production in Transdanubia, western Hungary saw a 15 % drop due to the lack of water. Fish was significantly more expensive than last year, meaning live carp was the most wallet-friendly choice and still 40 % more expensive compared to last year, while prices of processed fish fillets and fish slices cost even more [7].

According to the Central Statistics Office KSH, the **overall agricultural production** in 2022 decreased by 19 % compared to 2021. The production volume of plant cultivation decreased by 28 %, and cereal yield decreased by 37 % in overall, including yields of corn which fell by 57 %, the oats by 51 %, rapeseed by 38 %, sunflower by 35 %, the rosé by 32 %, wheat by 18 %, and barley by 10 % [8]. According to the estimate of the Institute of Agrarian Economics, producer **prices** rose by 46 % this year, but the quantity of the products decreased significantly, especially in crop production, which produced more than a quarter less [9]. This year domestic animal breeders had to deal with many challenges, among others pastures burnt due to drought, **poor breeding results, lack of fodder** and the skyrocketing feed prices due to drought. Fodder was already expensive at the beginning of the year, and during the year, due to early and long-lasting drought, the main question became whether there would even be enough **food for cattle** regardless of the price. As a result, some milk producers were already forced to buy bulk and fiber feed from other counties [10]. According to the National Hungarian Hunting Chamber, although **game farmers** did not notice mass deaths due to drought, the number of reared animals decreased and reproduction was lower, especially in the case of small game, such as hare. They tried to compensate for the lack of water by placing drinkers and juicy feed [11, 12].

Drought in 2022 undoubtedly caused the greatest damage to agriculture. According to the Ministry of Agriculture, 46 % of Hungarian territory was affected by drought in 2022. By the beginning of September, agricultural producers **reported drought damage** on 1.35 million hectares, which is almost eight times the area reported for the same period in the years 2017-2021. Approximately 30 % of the agricultural output was lost due to drought, and economic losses are estimated at around 500 billion HUF. Agricultural **insurance companies** have paid out 39.96 billion HUF for this year's drought damages, following nearly 8500 notifications until the end of October, the Association of Hungarian Insurers announced. According to their estimate, severe drought reduced **GDP growth** in 2022 by 0.6-0.8 % [13, 14, 15, 16].

Due to drought, the water level of **surface streams and rivers**, as well as **groundwater levels** decreased significantly throughout the country. Due to low water levels of lakes and rivers in March already, first and second level of preparedness had to be ordered as a result of the prolonged water shortages in the areas of eight water directorates [17]. At the initiative of the National Chamber of Agriculture, the Minister of the Interior declared in mid-March a period of persistent water shortage for the entire territory of the country. Due to the low rainfall period throughout all winter and early spring, water level in the Drava River was extremely low. In late March it stood 131 cm below its usual level, not far behind the lowest water level ever measured [18]. According

to the Directorate of the Hortobagy National Park, in late March most **wetlands** were still dry with only minimal water cover in larger areas [19]. Also in April, most of the lakes and rivers across the country were less than 50 % full, with warm season still ahead [20]. Water level in Lake Batalon reached record low in early May, and has not recorded as low in spring since 1921 [21]. In June, drought caused severe stress to freshwater **ecosystems**, especially fish ponds were struggling with a serious water shortage, according to the Hungarian Aquaculture and Fisheries Interprofessional Organization. Due to rainless winters of the last two years, the groundwater also receded deeply [22, 23]. The prolonged drought led to **water shortages** in some areas of Hungary, as ten settlements in Pest County, central Hungary and the water supplier DMRV asked consumers to reduce water consumption. In addition, the municipalities of some cities ordered **watering bans** [24]. In July, the water level of Lake Ferto, northwestern Hungary and Lake Velence, central Hungary dropped dangerously, Lake Nagyszeksos, southern Hungary completely dried up, a 15-kilometer section of the Bodva stream, northeastern Hungary also completely dried up, and a desert atmosphere prevailed in the Great Plain. The Tarna River, northeastern Hungary dried up completely, due to drought as well as concurrent permitted water withdrawal for irrigation by a winery company. The situation elevated **conflicts over the priority water use** in extreme drought in the view of business and ecosystem. Between Verpelet and Kapolna in country's north-east, cases of continuous illegal water abstraction took place, which was talked about as a serious ecological crime [25, 26]. **Fish population** also suffered from the lack of rain. Several places went for months without noticeable amount of rain, and evaporation due to the scorching heat rapidly dried up the lakes, altogether making water ecosystem hostile to their population and threatening spawning grounds [27]. In mid-August, the water level of the Lazberci reservoir in northeastern Hungary, considered a drinking water base, also started to drop significantly. The summer heat wave did not spare Tapio River either, which completely dried up at Jaszboldoghaza in central Hungary, which occurred for the first time in history. The **animal life** along the stream disappeared and the grassland was burned [28]. Despite a large amount of precipitation in September, the water level of Lake Balaton was still extremely low. It gave an idea of how dried the surrounding land was as it is typical that the precipitation is first absorbed by the soil and the plants with great intensity after the dry summer. Similar situation remains at the end of September for Lake Velence, central Hungary. There was no water in its catchment area either, meaning the water level could be increased by inflow but it depended entirely on effective precipitations [29, 30].

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SLOVENIA

Slovenia recorded severe agricultural and hydrological drought in 2022. Of agricultural crops, most affected this year were **silage corn** and **permanent grasslands**. First estimates of the corn harvest indicate losses of between 40-60% on average, especially on shallow soils where they could be as high as 80 % [1, 2, 3, 4]. Most farms produced only half as much **hay** as they would under normal conditions. Instead of the usual three to four mowing cuts per season, most farms collected poorer first cut, heavily reduced second cut while there was no third cut at all due to no precipitations and extremely high air temperatures, and **livestock grazing** was in early August no longer possible [5, 6]. In addition to lesser hay harvest, quantity as well as quality of the corn harvest was catastrophic and put livestock feeding until the next harvest at risk [4, 7, 8]. Yield of **stubble crops** was also lower than last year, according to the Statistics Office. **Potato** yield is also expected to be reduced, compared to last year. In Gorenjska region, northwestern Slovenia potato yield on rainfed plots was reduced by 35-60 %, and the quality of the harvest also worse, which was expected to further affect purchase prices. **Vegetables** on plots without irrigation were reduced by up to 90 %. There should be about 40 % less **hops**, too [4, 5, 6, 9]. According to September record of data, this year's harvest of most **late-season crops** was below the 10-year average, and also **wines** yielded less, according to the Statistical Office [10]. Although the harvested amount varied by region, there was less wine produced overall, especially in the country's south-west. The production this year alone was 20-25 % lower than the average, and wine stocks were the smallest in the last 30 years [11]. **Olive** harvest was also well under-average this year due to drought. The oil content in the fruits remained high and the olive oil expected to be specifically bitter. Drought and high temperatures took their toll also on **peach orchards** in Vipava, western Slovenia. Of the harvested ones, fruits were of good quality although in plantations without irrigation the fruits were small, but the yield itself was expected to be 30-40 % lower, according to the Agriculture Advisory Service Nova Gorica [12, 13, 14].

Spruce trees noticeably weakened due to scorching heat and drought this year, which accelerated progression of bark beetle in spruce forests. According to the Slovenia Forest Service, worst situation was observed in Crna na Koroskem and Upper Savinja valley in the country's north-east, in Gorenjska region in the north-west and in Kocevska region in southeastern Slovenia [15]. Across the country, **forest** acquired autumn colors in August already, with leaves observed falling down, indicating exceptional heat and drought stress as even trees with deeper roots suffered severe hardship due to drought [16]. In the Zelenci **wetland** nature reserve, northwestern Slovenia this year's drought markedly worsened the situation. Even in November the water level remained very low. According to the Kranj unit of the Institute for Nature Protection, such low water level has not been observed in the past 25 years, not even in the so far worst drought in 2003 [17, 18].
At the end of June, Administration for Civil Protection and Disaster Relief declared a major fire threat first in the area of Ajdovscina municipality, western Slovenia, and by July it extended its warning to the entire country [19, 20]. Due to severely dry topsoil level and scrubs, massive **wildfire** broke over the Karst area, western Slovenia in mid-July, which in addition to on-going drought was maintained by heatwaves and strong winds, while fire extinguishing was difficult due to, among others, the hydrological drought in surface- and groundwater. It lasted for over two weeks and burnt the total area of more than 3,500 hectares, making it the greatest wildfire in country history. The emergency engaged over 10,000 firefighters and army support units, and ground and aerial help from other EU countries [21, 22, 23].

Precipitation deficit in winter and spring months, and lack of rain in summer months caused great **hydrological drought** in Slovenia. Lack of snow in the highlands, which melted away in early spring already, was a reason for a reduced inflow of water from the mountains in the summer, thus contributing to lowered water levels and higher water temperatures, some of which were measured as high as ever [24]. The temperature of several surface waters, including Sava, Vipava, Krka and Kolpa in their lower reaches as well as Lake Bohinj and Lake Bled, rose to 24 °C in mid-July, and a lot of **algae** appeared [25]. Critically low water levels had been measured since the end of June at nearly all rivers in western half of the country, including Sava, Ljubljanica, Vipava and Soca [26]. The prolonged drought, which caused very low water levels in rivers and tributaries, also had a strong impact on **fishing tourism**. A number of Fishing Families across the country, including in Alpine and other mountainous regions, had to intervene upon **dying of fish** and rescuing the existing one, and had to prohibit sports fishing for the first time ever. These included the fishing area of Lake Cerknica and Rakov Skocjan in country's south-west, most of the Soca River tributaries in the country's north-west, and Ljubno at Savinja in northern parts of the country [27, 28, 29, 30, 31]. Due to drought-related fish death and disease outbreaks, as well as loss of numbers of feed days, economic losses in **fish farming** were estimated at around half a million EUR, according to the Chamber of Agriculture and Forestry Slovenia [32]. Due to the low water levels, **river tourism** in the area of the Julian Alps, northwestern Slovenia was also affected as adjustments were necessary in a form of limitations or bans, higher costs and organizational problems, less people placed in the rafts, and sometimes even non-feasibility of even taking to the river. The operators therefore had to temporary stop all river tourism activities [33].

Throughout summer months, many municipalities across Slovenia faced severe **shortages of drinking water**, most noticeably in western half of the country, and drinking water had to be delivered to the regions, according to the Administration for the Civil Protection and Disaster Relief [34]. By the end of July, use of drinking water was prohibited for any non-essential use as well as for filling fire cisterns without the prior consent of the water supply company. Among others, it was restricted in Novo mesto, Spodnja Savinjska dolina, Ajdovscna, Vipava, Kozjansko, Zalec, Obsotelje, Kranj and Murska Sobota. Four Slovenian coastal municipalities including the regional capital Koper closed all water systems for showering on all beaches and for fountains in public places [35, 36]. In mid-July, the ban on the use of drinking water was extended also for watering agricultural land and other uses in agriculture, and other business entities were urged to reduce water consumption by 30 %. The supply of drinking water was very limited even for ships docking in the port of Koper [37, 38]. Municipalities of Ajdovscina and Vipava in western Slovenia prohibited any use of water other than for primary supply from 6 to 9 in the morning and from 6 and 11 in the evening [39]. To several municipalities in Slovenian Istria, whose sources of drinking water dried up, water supply was ensured by transporting from other regions in the country and by **buying water** from Croatian Istrian water supply [40, 41]. Agricultural Forestry Institute Nova Gorica, western Slovenia reported of an increasing **pressure from wild animals** (wild boars, roe deer, deer...) which in search of food and water caused great damage to arable land and orchards, but also from insects, such as mites, lice, leaf miners, bed bugs, moths and others [42]. Water shortages due to lack of precipitations were a severe problem also for **mountain huts**, mostly in the high mountains whose water supply relies entirely on rainwater. Many mountain huts had no water to offer for either food, drinking consumptions or sanitary needs [43, 44].

According to the operators of hydropower plants on the lower Sava River, eastern Slovenia, hydrological drought in 2022 was the worst for **electricity production** in the past 17 years. Due to low water level and thus high water temperature, also Nuclear Power Plant Krsko in eastern Slovenia had to activate reserve cooling [45]. Due to the extremely low flow of the Soca River, the

Solkan hydropower plant temporarily stopped operating in mid-July, which happened for the first time since 2003. Also the rest of the power plants on the river operated at a very limited extent - of 22 small hydropower plants that fall under their umbrella, five were not working due to lack of water, and most of the others were switched on only occasionally. According to the Slovenian Powerplant Holding, electricity production on Drava River was 31 % lower, on Soca River 45 % lower, and on the lower Sava River 39 % lower compared to the previous five-year average in the same period [46].

On the other hand, **salt farmers** in Slovenian Istria recorded a really good harvest in year 2022. Salt harvest began in mid-June already, which is a month earlier than in recent years, and have by the end of July already collected under 1,500 tons of salt which equals the last year's yield [22].

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CROATIA

Spring drought along the Adriatic Sea, especially in Dalmatia was more pronounced than elsewhere in the country taking into account the different soil texture compared to the continental part of Croatia. In the continental regions in spring, especially in Slavonia, crops did not receive **timely fertilization** with mineral fertilizers and their stagnation was observed with occasional yellowing, as a result of long dissolution of solid mineral fertilizers due to lack of precipitation. Wind also contributed to the drying of the surface layer of the soil and spring sowing was already in question. Young fruit trees required additional amounts of water, which increased production costs. Drought also affected **livestock and grazing** in the absence of fresh young **grass**, which

stagnated in growth. The accumulated precipitation in winter and spring months was still too little for the successful continuation of the vegetation growing season, especially in the eastern parts of the country [1, 2, 3, 4]. In the continental regions, the negative effect of the lack of precipitation during the first part of May was seen in the slow growth of green crop biomass. [5]. According to the reports of the Osijek Agricultural Institute, the costs of **wheat** production increased, especially for mineral fertilizers, so that the **price** of mercantile wheat on the market was quite high in June. Wheat yield wase 10-15 % lower than the last, record year. **Cattle** were also exposed to heat stress not only in the dwellings but also in the pastures. The cattle's appetite was reduced, and the need for water increased. **Olive** fruits were smaller in size, threatened were also **orchards, vineyards** and mandarin plantations where yellowing of leaves and shriveling of fruits were visible in June. The **intrusion of the sea** into the Neretva River occurred due to low water level in the river, which became a problem for watering agricultural crops. Drought significantly reduced the yields of **cabbage, watermelons and tangerines** [1, 2, 3, 6]. Due to the continuation of the dry period during July and even more frequent heat waves, **maize** yield was reduced by 50–60 %, **soybeans** by 30–50 %, **sunflowers** by at least 25 %, and mandarins, **apples**, and olives by 30–50 %. Also **vegetable** yields regardless of irrigation were reduced by about 30–40 %. In some parts of the Bjelovar-Bilogora County, continental Croatia, potato yield was up to 70 % reduced. In addition to overall reduced yields, **production costs increased**, especially for growing vegetables due to increased need for irrigation. Most of the olive groves and vineyards do not have irrigation, so some farmers had to bring water with cisterns and water the plantation. Such extreme weather conditions were a great stress not only for plants but also for animals looking for shelter and drinking water. High temperatures and drought drove **wild animals** from their habitats into urban areas in search of water. Local communities in Istria, northwestern Croatia organized water supply for wild animals through watering holes [1, 2, 3, 7, 8, 9]. In August, drought affected all parts of the country and adversely affected agricultural production. Drought damage in Medjimurje was 100 % on certain field crops, while the yields in orchards were on average about 30 % lower. In general, due to drought, harvests started earlier in both orchards and vineyards. In continental vineyards, **grapes** were of high quality and supremely sweet but the yield was altogether reduced. The consequences of drought were also visible on the islands, especially at the central Dalmatian ones, where it had not rained in months. Many islanders harvest **blackberry** fruits in August, but this year the blackberries dried up before ripening. The grass on most island **meadows** was completely dry. In the absence of rain, **drying of springs** and ponds on the island was a big problem [1, 2, 3, 10]. Due to drought, and consequent **shortage of fodder** and even higher production prices, livestock farmers were particularly negatively affected. **Milk production** became almost 100 % more expensive, and on Krk Island, lack of fodder and water resulted in sheep losing some of their weight, affecting sheep **cheese production** [11, 12].

A prolonged drought emptied village wells in Djakovo, eastern Croatia. Situation was the worst in the municipality of Levanjska Varos, where several settlements do not yet have a water supply network and its inhabitants depend exclusively on wells [13]. Water levels at the source of **drinking water supply** for the municipality of Brinje, northwestern Croatia, also reached lowest levels ever recorded. Fire brigades had to be activated to deliver drinking water for sanitary needs and livestock. Also **tourism** workers suffered big losses [14]. In Rakovica, central Croatia, water supply company had to temporary completely suspend drinking water supply to its residents every night from midnight to 5 am [15].

Due to the long-lasting drought, water level of several rivers and lakes throughout Croatia were particularly low. The **water level** of the Sava River in Zagreb, the country's capital was so low the river could be walked across [16]. Drought that lasted for months also caused problems for

freshwater ponds, endangering **freshwater fish farming** due to lack of water. The level of several Slavonian ponds, eastern Croatia was at a historically low level, more than two meters short of the maximum water level. Some ponds were almost 80 % empty [17]. Drought greatly reduced water levels of two main navigation rivers, the Drava and the Danube, so **cargo ships** could not reach Osijek in the country's east [18]. The combination of unfavorable hydrological circumstances and the increase in the cost of importing electricity and energy fuel (natural gas, coal) affected the **Croatian Electric Industry** in the first half of the year [19].

In 2022, 17 counties in Croatia declared a **natural disaster** due to drought, for the areas of a total of 281 local self-government units. According to the first estimate, the damage in the area of Medzimurska County alone amounted to about 150 mio HRK [20, 21].

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BOSNIA AND HERZEGOVINA

According to the Association of Farmers of the Federation of Bosnia and Herzegovina, drought caused enormous damage to agriculture across the country, especially to **corn and silage corn**. In several localities, corn yield losses were 20-80 % and in some places the damage was total. As stated by the Association of Agricultural Producers of Republika Srpska, even on plots with a deeper structure where full agrotechnics were carried out, only up to 30 % of the usual yield was gained. In addition to corn, also **grass fields** were greatly damaged, which directly affected livestock sector [1, 2, 3, 4, 5]. Up to 20 % lower than expected was also **sunflower** yield across the country [6]. Also affected were **fruits** and vegetable crops, including **cabbage**, whose yields was reduced by up to 50 % [7, 8]. **Grape** harvest, which due to drought took place almost a month earlier than normal, was in Krihari, northwestern Bosnia and Herzegovina slightly worse than the previous year but of good quality [9].

The volume of **milk production** in the municipality of Sanski Most, northeastern Bosnia and Herzegovina decreased by about 20 % due to drought and rising production costs. Some farmers were forced to reduce the number of cows or close their farms. Also in Tuzla Canton, eastern Bosnia and Herzegovina, this year's corn yield was almost halved and despite reseeding some of the crops they did not grow and develop beyond a meter of height. It presented severe threat of not having enough **food for cattle**, forcing livestock farmers to **sell their cattle**. With lower grain yields, poultry farmers expected increase the **price of all poultry products** by 10 % [10, 11, 12, 13, 14].

In high temperatures and the absence of summer meadow grazing due to drought, **bee colonies** were affected. The meadow pasture for bees was practically burned and in dried land they were

left with little or no water nearby, which had direct consequences on a smaller amount of **honey** and therefore a financial blow to beekeepers. Additional damage by drought was caused to the bee colonies themselves, which would have a problem preparing for the winter. The price for a kilogram of honey throughout republic of Srpska, which usually sits at around 25 marks, rose up to 30 marks [15, 16, 17]. This year's drought noticeably affected the amount and quality of **blueberries** from the slopes of the mountain peaks in Foca, southeastern Bosnia and Herzegovina [18]. **Wildfires** were reported in municipality of Bileca and also near Lake Boracki in municipality of Konjica, southern Bosnia and Herzegovina [19, 20, 21].

The Government of Posavina County in the northeastern part of the country declared a state of **natural disaster** due to drought. Almost all agricultural areas were affected by drought, and there was a decrease in yield and quality observed for all arable crops (except winter ones), fruit and vegetable and in beekeeping products. Due to severe drought and **water shortages**, a state of emergency was declared also in several local communities of the Banja Luka region, northern Bosnia and Herzegovina [22, 23]. The water supply company of Banja Luka reported of problems with water in the outskirts of the city due to which it declared a state of emergency in eight local communities. It had to change the operating water supply regime in order to fill the Tunjice reservoir and normalize the water supply in the surrounding settlements. The measures included **reduction of water supply** to certain local communities where possible, increased controls by the city's control bodies and the police, given there were problems and losses of water on pipes, hydrants and connections [24, 25, 26, 27, 28]. Due to the insufficient water inflow in the catchment area at the Zeleni Jadar locality caused by drought, more serious water reductions were introduced in Srebrenica, eastern Bosnia and Herzegovina for the first time in eight years. Regime meant that half of the population had reductions in place from 8 p.m. to 6 a.m. every other night, and so alternately until the source was filled again [29, 30].

Significant decrease of **water level** in Drina River since the beginning of July caused a significant decrease in the water level also in the canal system in Semberija. Works were carried out to deepen a part of its river bed and the connecting channels, so that in the on-going dry period more water from the Drina river bed could reach the canal system in Semberija, and in this way provide sufficient amounts of water for functioning of the irrigation system [31]. For the second time in the last five years, due to a severe drought, the water level significantly decreased in Lake Bilec [32].

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SERBIA

In June already, soil on many fields in Serbia appeared cracked and drought impacts could already be seen on crops. Irrigation was increasingly necessary, which increased water consumption during drought [1, 2]. As part of the preventive measures, the City Council of Uzice, western Serbia issued an Order **prohibiting use of drinking water** for nonpriority water use, such as watering yards, gardens, orchards but also agricultural crops [3]. Despite that, drought left considerable impact in agriculture production in Serbia, great damage was observed especially on **corn** and **soybean**, to lesser degree **sunflowers** and **vegetables**. In Banat region, northeastern Serbia, approximately 70 % of corn plots were left burnt due to drought and hot days. The cereal yield was sufficient only to ensure domestic needs and slightly more for the export, which is far below Serbia's usual grain potential [4, 5, 6, 7]. Drought was also the primarily factor in **price increase** of practically all types of fresh vegetables, including **potatoes** [8]. Dry winter and prolonged periods of dry weather throughout spring and summer reduced **plum** yield by a third compared to last summer. In addition to poor quantity, also quality of fruits was reduces as during drought stress plum tree draws water from the fruit, even from the leaves. Remaining fruits were mostly used for brandy, while as sold fresh they did not meet good quality [9]. **Vineyards** were also reported of experiencing drought damage, especially in northern half of Serbia. In Slankamenac Vineyards in northern Serbia, harvest took place much earlier, already in early September, with yield reduced as much as 50 % and of lower quality [10]. Banat region in northern Serbia too reported of dramatic impacts of drought to their vineyards, including drying of leaves on the vine and with grapes having small, unassembled berries. The yield was lower and its quality was questionable [11, 12].

In July, **water levels** on most rivers in Serbia were very low, close to biological minimum. Most severe was the situation on Sava River near Sabac and Sremska Mitrovica, northwrestern Serbia while hydrological warnings were soon afterwards introduced for Danube River, especially on the account of severe water level situation in the upper course of the river. Both rivers are important transport rivers through which the majority of grain exports and coal imports go. **River transport of cargo ships** departing from Bulgaria and Romania was significantly affected, both in reduced traffic as well as in reduced capacity of individual vessel. At the same time, Drina River in western Serbia was in some places so shallow it could be walked across, and due to the drop in **groundwater levels**, drought and heat, Lake Jamurine was on the verge of completely dying out [13, 14, 15, 16]. In August, water level of the Danube River fell to one of the lowest in almost hundred years. On the water border with Romania where Danube usually flows powerfully, more than 20 German warships sunk in the WWII were discovered near the Serbian port town of Prahova. Danube river banks in Serbia resembled long sandy beaches in August, while sandy banks were also found in the middle of the river. River transport was to some degree enabled by **deepening the river bottom**. Also lower reaches of Danube River continued to present serious troubles for supply of crude oil, diesel and other derivatives in August, due to a three-week **suspension of navigation** on the Danube in Bulgaria [17, 18, 19, 20]. Especially Vojvodina, northern Serbia experienced severe **hydrological drought**. Due to insufficient rainfall and high air temperatures, **dead fish** were observed in the little water left in Conopljan Lake near Sombor. The lake gradually disappeared, causing ecological disaster this summer as the entire **ecosystem** collapsed due to the lack of water. The remaining fish had to be transported to the nearest Danube-Tisa-Danube channel. Herons, roe deer, wild ducks and protected bird species were endangered to disappear

along with the lake water [21]. Due to extreme lack of water, **irrigation ban** was introduced in parts of Vojvodina. Suspension of irrigation was put in place for the Moravica, Zobnatica and Sava reservoirs as the water level in them dropped to the all-time low. 3,200 hectares were normally irrigated from these reservoirs, however, the ban remained in effect until the increase of water levels but which, due to hydrological drought being present in wider stretches of the region, could not be replenished with water from watercourses or canals in the region but depended entirely on rainfall [22]. Significant drop in water level was in August observed also for Djetinja River downstream and through the center of Uzice, western Serbia. The inflow of water from the Lake Vrutci, which serves for the city's **water supply**, but also from the tributary river Susica in Zatibor, was in August extremely weak. Djetinja's water level downstream was in August even below the biological minimum [23]. Extremely low water levels across the country reduced also **electricity production**. According to the EPS hydropower plants, the hydrological situation had not been as bad in the last almost 100 years, due to which the hydropower plants on the Danube, Drina and Lim produced minimal amounts of electricity [24]. Altogether, the main 16 hydroelectric power plants in Serbia, which produce 38 % of total national electricity, had to reduce their production by up to 35 % [25]. Hydrological situation on rivers Lim and Uvac was the worst in last 10 years. According to the director of Lim hydroelectric plants, inflow to Lima was in August significantly less than the biological minimum released under the Potpec hydroelectric plant [26, 27]. The Djerdap hydroelectric power plant, which provides about a fifth of Serbia's electricity, also operated at the biological minimum as its water level was only once in last 100 years lower than in 2022 [16, 28].

Sector of Ecology and Environmental Improvement, which monitors mosquito larvae and adults, reported a very low number of adult **mosquitoes** in the traps compared to previous years, as high air temperatures, higher number of tropical days and small amount of precipitation reduced the number of these insects. In addition, the low water level of the Sava and Danube also played role in fewer mosquitoes, due to no flooding of the coastal part of the rivers where the larvae of river mosquitoes develop, which, as they emphasize, are the most common area in Belgrade [29].

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MONTENEGRO

The most severe consequences of drought in Montenegro in 2022 were reflected in forest fires, significantly reduced water levels in rivers and lakes (some even dried up), problems in water supply for population and livestock, and in reduced electricity production. The long-term drought affected mostly **livestock** and farmers due to the lack of water, reduced yield of **hay** for livestock feeding and the increase of the **price for animal feed**. Based on the information of farmers in Niksic and Savnik, central Montenegro, the yield of hay was halved, compared to the average. Since also the year before was unproductive, many livestock farmers announced that they had to sell the livestock (poor yields, increased price for hay). The crops were also affected by the drought. In the surroundings of Niksic, the yield of **winter cereals** was lower by about 30 % compared to the last year, and in some parts of Pljevlja, northern Montenegro up to 60 %. Agricultural plants with deeper root system (fruits and vines) were less affected than arable and vegetable crops, and their yields were expected to be satisfactory. Based on drought monitoring and analysis of the SPI index, drought watch tool and precipitation analysis, it can be said that during and at the end of September the agricultural drought ended in all parts of Montenegro. However, the end of the drought in September came too late for most agricultural crops and the damage it caused in the past period was irreparable.

Many parts of the country experienced **forest fires** during July and August. Most severe fires and very difficult to cope with were in the north-west in the Municipality of Niksic, Savnik, Zabljak and Pluzine, and in the coastal area (Boka Kotorska Bay and Municipality of Bar). Helicopters, police aviation and the army of Montenegro took part in extinguishing them almost every day. Settlements and inhabitants were endangered, and roads and rail traffic was interrupted from Bar to Podgorica while 100 firefighters with 47 vehicles, locals and volunteers took part in extinguishing the fires. At the same time, several location also in the Boka Kotorska Bay was affected by forest fires. Fires followed strong winds and high temperature above Morinje, Kamenar and Zalaza. The cause of forest fires in the hills above Kostanjica and Perast was lightning strike. The consequences from this summer fires were not yet estimated but they were multiple and large considering the forest area, air pollution, losses in tourism and material costs for firefighting. The last major forest fire occurred in late September the vicinity of Ulcinj, on the Pinjes hill, where a large area of pine forest burned. The fire was under control on 21 September by coping from the ground and from the air, but it was completely extinguished on 23 September.

Drought greatly reduced **water levels** of rivers, natural and artificial lakes. These left severe negative consequences to **ecology, tourism** and **electricity production**. Particularly low water level and rapid disappearance was observed for Lake Biogradsko on Bjelasica Mountain in the National Park, eastern Montenegro. Very low water level were recorded in artificial lakes Krupac and Slano near Niksic, and Piva near Pluzine. Many water bodies had severely low water levels and some of them even dried up in August. This caused problems in **water supply** in some places, for the public but livestock too. Due to drying up of watering ponds in some pastures and katuns of Durmitor, northern Montenegro, livestock farmers were forced to move their herds to lower areas where water was available. At the end of July, several municipalities imposed restrictions in water supply (Berane, Niksic, Bar and Kotor). Since significantly less water accumulated in the lakes (e.g. 60 % less for hydropower plant Piva), and with higher consumption of electricity during the tourist season, 294 GWH of **electricity needed to be imported** in August, causing additional costs of approximately 100 million euros, as announced by Electric Power Company of Montenegro. The **hydrological drought** continued in September although it decreased in intensity. **Groundwater levels**, the recharge of which is a prerequisite for surface water to

appear, were still low, so the hydropower sector was in autumn still significantly affected. The long-term hydrological drought in western regions of the country, where two large hydroelectric plants are located, directly contributed to the significant financial losses of Elektroprivreda CG. In the areas of the Piva and Zeta river basins, which hydropower plants reservoirs depend on, rainfall deficit was very pronounced. In normal years both hydropower plants produce 45 % of the required electricity but due to severe hydrological drought the **import of electricity** significantly increased in the last nine months. Instead of a profit of at least 133 million euros, Elektroprivreda CG had a loss of 57 million euros in this period, which, along with the unfavorable market movement of electricity prices, is a direct consequence of the long-term hydrological drought.

Photo 1: top picture - Crno Lake (natural lake, Durmitor National Park) in August 2022, source: Branka Čvorović. Bottom two pictures - Crno Lake on 18 September 2022, source: Danijela Minić.

Photo 2: Krupac Lake (artificial lake for hydropower plant Perucica) in August 2022. Source: Branka Čvorović.

Photo 3: Slano Lake (artificial lake for hydropower plant Perucica) on 6 September 2022. Source: Mirjana Ivanov.

Photo4: Lake Moraca (Podgorica, near Millennium Bridge) on 13 September 2022. Source: Mirjana Ivanov.

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ROMANIA

According to the Ministry of Agriculture, by the first week of September 470,000 ha of agricultural land were reported affected by drought, of which slightly less than a half presented wheat plots, almost a quarter corn plots, followed by sunflower, other cereals and about one eight being rapeseed plots [1]. **Wheat** yield was about a fifth lower than in 2021 due to high temperatures and prolonged winter and spring drought. Taking the average domestic consumptions into account, it was enough to meet domestic needs with some surplus left for the export, although less than expected. Drought affected also **corn** and **sunflower** crops and forced some farmers into an earlier harvest. Due to reduced production, sunflower and **olive oil** was expected to be sold at higher prices [2, 3, 4, 5, 6]. Of fruits, most affected was table **grape** production, which was halved due to drought [7]. The heat and drought made the **truffles** in forests appear almost a month later. Some managed to harvest only a quarter to half of the amount obtained last year. The fact that they are few made them even dearer – depending on the quality, they could cost triple [8].

The **restrictions on water consumption** imposed due to the drought in several parts of the country pushed some Romanians to look for alternative solutions, dig wells in their yards [9]. In Zimnicea, southern Romania, dozens of **cargo and tourist ships** were blocked due to the low **water level** of the Danube River. Only a narrow stream of water remained from the Danube and a huge stretch of sand appeared. Where river flow was still present, water was no deeper than 1.40 m, barely reaching chest height. It greatly affected **river transports** as heavy ships and cruise ships could no longer pass and were forced to remain waiting, while other boats had to let go of their cargo in order to become lighter and thus be able to move forward [10]. A blocked Danube river transport causes a domino effect in the logistics chain in Romania and beyond. These delays in logistics reflected in **increased prices** to the end consumers [11]. Some cruise ships were forced to disembark their tourists as the ships could no longer move forward. At the same time, **energy production** also decreased. Hydro plants reached only a third of last year's production. At Cernavoda nuclear power plant, due to the reduced water level, the first level of warning was also reached. Water flow of the Danube River at Bazias, where it enters Romania, was less than half of its usual one [12].

In **Danube Delta,** six lakes completely dried up, and dozens more were on the verge of disappearance in September. Instead of waterholes where **fauna and flora** of the reserve thrived and used to attract thousands of tourists, only kilometers of dry land could be seen and the fish in danger of suffocating. The most affected were the lakes near town Tulcea [13]. The water in Lake Techirghiol, the largest salt lake in Romania, dried up over a considerable portion of area, over the distance of at least 50 m from its original shore, and was close to disappearance. The lake was over seven and a half kilometers long and nine meters deep. Normally, the water level should reach the pontoon but the entire shore of Lake Techirghiol was dry, and the boat was left stuck in the mud. As the area is considered a natural site, people cannot intervene. There was also less mud famous for its therapeutic properties, which could also be reflected in the price of the therapies [14].

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GREECE

In July, persistence of high temperatures, combined with drought and generally strong winds, favoured **forest fires** in many areas mainly in eastern and southern Greece. The most disastrous ones occurred in Penteli (Attica), in the Dadia Forest National Park (Eastern Macedonia and Thrace), in the island of Lesvos, in Ilia (Peloponnese), and in Rethymno (Crete). In Penteli, more than 20 000 acres were burnt based on information from the Landsat 9 satellite. The Secretary General of Civil Protection declared the Municipality of Penteli a state of emergency for six months in order to restore the damage and problems created by the catastrophic forest fire that occurred on 19 July [1, 2]. In the Dadia Forest National Park, the fire that broke out on Thursday 21 July lasted several days, threatening the unique ecosystem of one of the country's most important protected areas. According to initial estimates by the Forest Service and other officials, at least 25 000 hectares of the forest natura, or 10 % of its total area, have been incinerated [3, 4]. In Lesvos, it is estimated that the fire has burned about 17 000 acres of pine forest and agricultural crops. In Ilia it is estimated that about 7 000 ha of pine forest and olive groves were burnt, and many animals in the pasture farms in the area have been burnt [3]. In the municipality of Agios Vasileios, in southern Rethymno, more than 15 000 acres (olive groves, greenhouses, and vineyards), beehives and livestock have been burnt [5].

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Methodology

DMCSEE Drought monitoring bulletin is based on numerical weather prediction (NWP) model simulations over SE Europe, SPI index calculations, remote sensing product and public media drought impact reports. Precipitation data is provided by Global Precipitation Climatology Centre (GPCC; https://www.dwd.de/EN/ourservices/gpcc/gpcc.html) shown against the average of the 1961-1990 time period. NWP simulations are performed with Non-hydrostatical Mesoscale Model at ~7 km spatial resolution (NMM; http://www.dtcenter.org/wrf-nmm/users/). Historical model climatology in terms of air temperature and surface water balance is computed with NMM on the base of 1 January 1991 to 31 December 2020 time period, using European Centre for Medium Range Weather Forecast (ECMWF) ERA5 dataset (http://www.ecmwf.int/en/forecasts/datasets/reanalyses-datasets/era5) as input for simulations. Long-term averages (1991-2020), used for comparison of current weather conditions, are obtained from simulated dataset. Comparison of current values against long-term average or in percentile classes (the two extreme classes with a 5-percent range and each of the middle three classes with a 30-percent range) provides a signal on potentially ongoing drought. Remote-sensing product in the bulletin is based on the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Land SAF MSG Daily Fraction of Vegetation Cover product (https://landsaf.ipma.pt/en/products/vegetation/fvc/), presented for the checked and confirmed locations and using long-term averages from 2004 to the last full year (currently to 2021). Information on drought impacts are obtained from freely available online reports of national authorities and media newspapers.