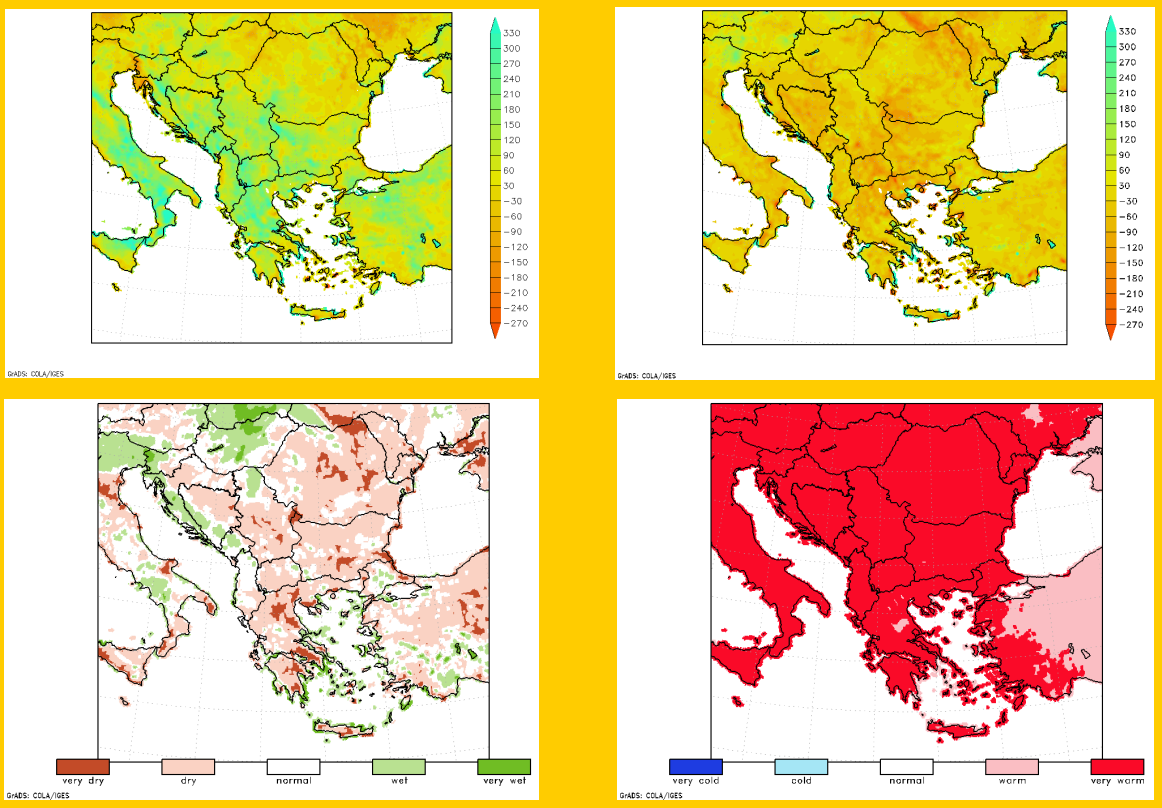
DROUGHT MONITORING BULLETIN

Overview from January to December 2023

HOT SPOT



Top left: ***accummulated surface water balance anomaly for 1 April–29 June 2023****. Top right:* ***accummulated surface water balance anomaly for 30 June–28 August 2023****. Bottom left and bottom right respectively:* ***60-day surface water balance*** *and* ***60-day mean air temperature for 8 September–6 November 2023 in percentile classes.***

For much of the region, April to June 2023 was a period of wet to very wet surface water balance levels. Most of the area including southern half of the region, central Balkan Peninsula and its western part recorded 3-monthly surplus of 120–240 mm, locally across wider central Balkan Peninsula about 300 mm or more. Nonetheless, far north-western part of the region and the northeastern quarter ended the April-June period in cumulative surface water balance deficit of 90–150 mm. In the following two months, July and August, most of the region experienced surface water balance deficit of 90–150 mm, especially in southern, central and western parts of Balkan Peninsula, as well as over north-east where deficit prevailed since spring already. Dry and warm weather continued into autumn. With the exception of the north and the north-west, September to October period brought 60–120 mm of surface water balance deficit, along with very warm air temperatures. The two-monthly mean reveal it was up to 4 °C warmer across the entire region, locally in Pannonian Basin and lower Danube basin up to 5 °C, ranking this period among the warmest 5 % of local records across all region. While vegetation season 2023 in most of the region followed a wet-to-dry shift in surface water balance conditions, prevailing deficit was the most common state in the region's north-east.

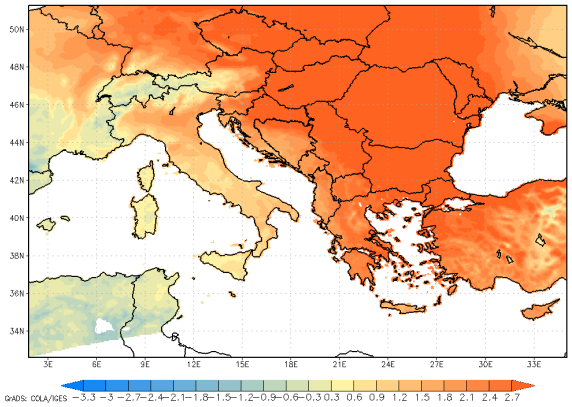
AIR TEMPERATURES AND SURFACE WATER BALANCE

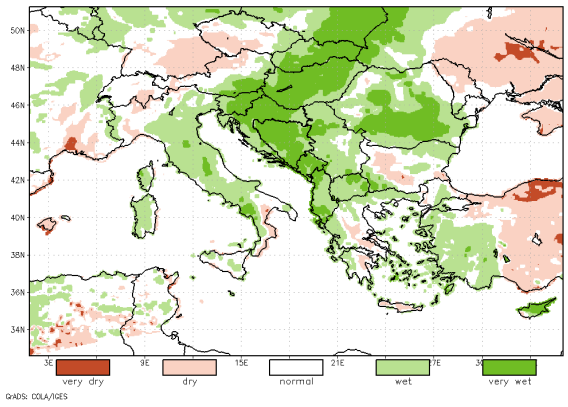
Figures in this section present deviations from the average of the 1991-2020 period of monthly ***mean air temperature (anomalies)*** *and monthly accumulated* ***surface water balance (percentile classes)*** *from* ***January to December 2023****.*

AVERAGE AIR TEMPERATURE ANOMALY [°C]

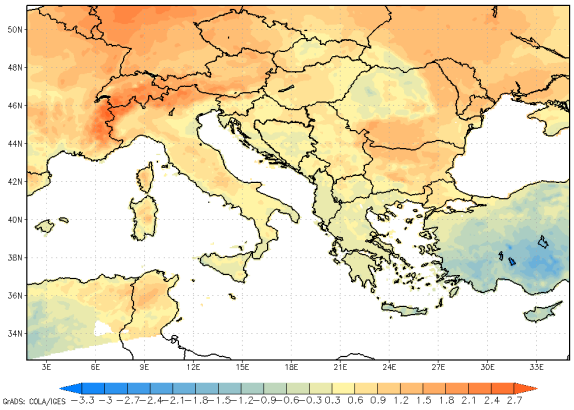
SURFACE WATER BALANCE [percentile classes]

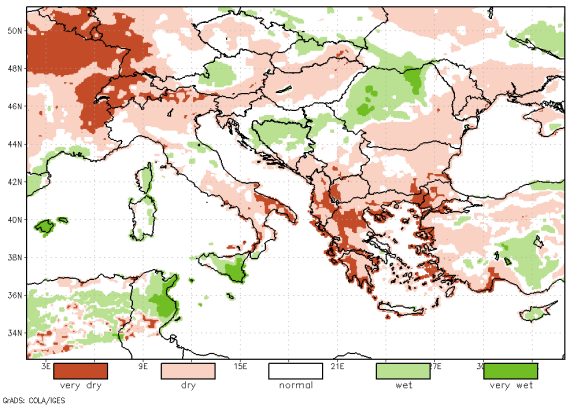
JANUARY 2023





FEBRUARY 2023





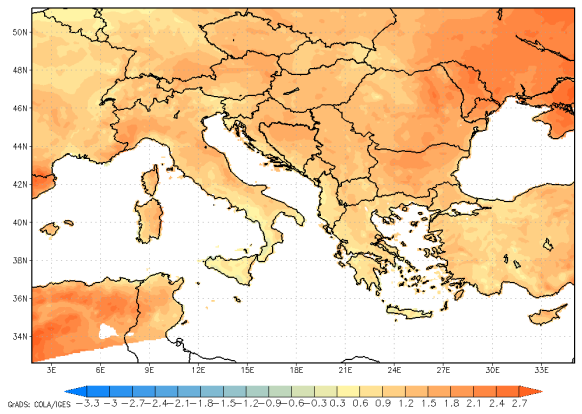
The year 2023 began with a much warmer than normal **January** across nearly the entire region, especially over the northeastern half of Balkan Peninsula and Aegean Greece where January ranked among the warmest 5 % of the 30-year record. It was wet to very wet month across much of the Balkan Peninsula, reflected in surface water balance surplus of up to 60 mm over Hungary, and up to 140 mm or locally even more along the Adriatic Sea and over southern Carpathians. January brought less than the usual precipitation amount to Moldova, central Greece, western Bulgaria and much of the central Turkey, resulting in surface water balance deficit of up to 40 mm over Moldova and western Bulgaria, and between 40 and 80 mm over central Greece and northern Turkey, locally in southern Turkey up to 120 mm.

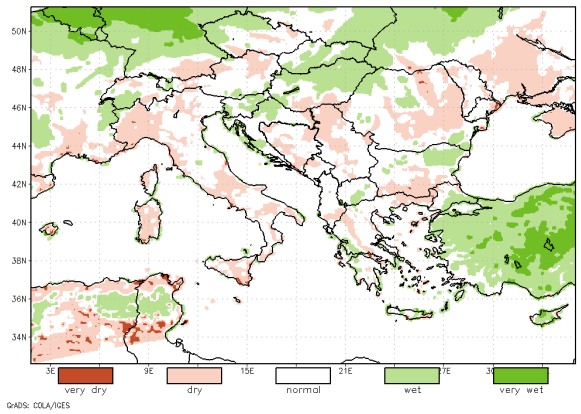
February mean air temperature was in general closer to the average, with greatest deviations reaching 1.5 °C warmer February than normal over Moldova and eastern and southern Romania, and up to 2 °C colder than normal month over much of Turkey, especially its southern half. Most of the region experienced a dry month, only a belt from Croatia to northern Moldova and central Turkey recorded monthly average or surplus levels of surface water balance. The rest of the region recorded monthly surface water balance deficit of up to 60 mm, while in the area from Montenegro, across central Greece to western coastal area of Turkey deficit ranged between 100 and 160 mm.

AVERAGE AIR TEMPERATURE ANOMALY [°C]

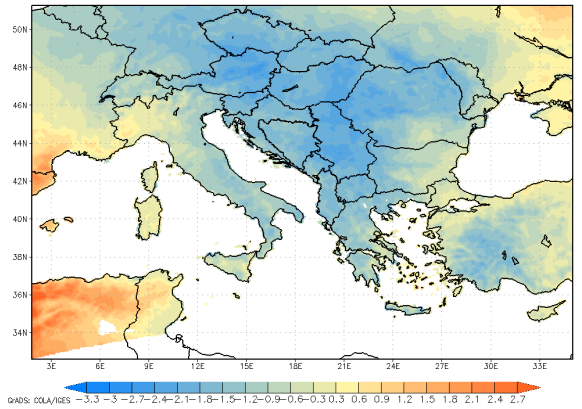
SURFACE WATER BALANCE [percentile classes]

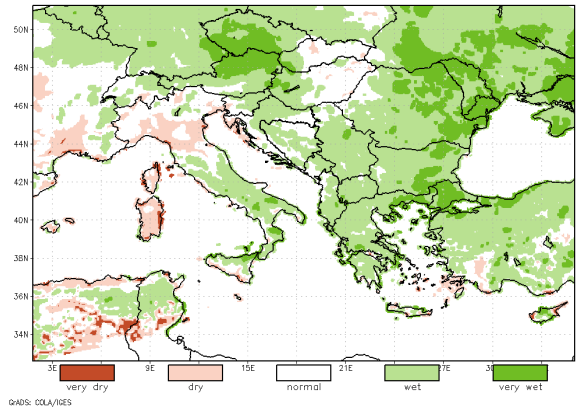
MARCH 2023





APRIL 2023





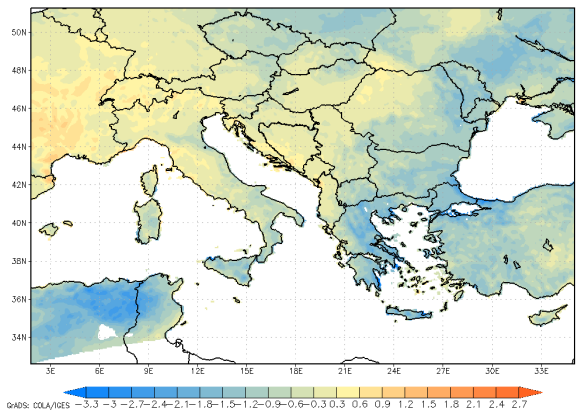
March continued a run of warmer-than-normal months for Moldova and Romania where monthly average stood 2–3 °C above the long-term average. It was on average 1–2 °C warmer than normal across the rest of the region, slightly less along the western Balkan Peninsula coastline and southern Greece. Precipitation level was unusually high over central Turkey where monthly surface water balance was 100–140 mm higher than normal, while over most of Greece, southern Bulgaria and in a central belt from Bosnia and Herzegovina to eastern Romania, March was drier than normal and ended up accumulating 40–80 mm of surface water balance deficit.

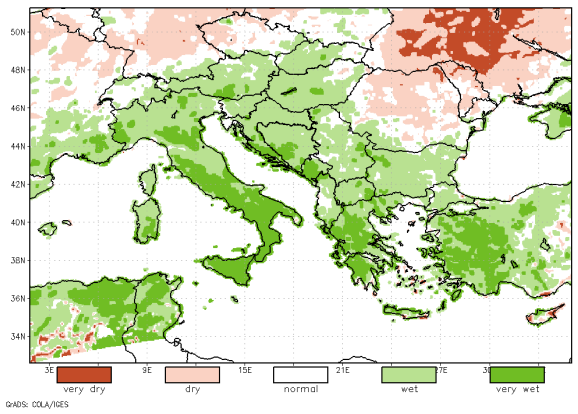
First days of **April** were characterised by cold air mass swiping across the region that brought much colder than normal air temperature for this time of year. End of the month was also colder than normal, resulting in April being between 1.5 and 2.5 °C colder than usual across most of the region, less so over the Aegean Sea area, eastern Bulgaria and northwestern and central Turkey. April brought precipitation relief to areas previously experiencing dry conditions, as above-average precipitation level was recorded over nearly the entire region, especially its north-east and east experienced very wet conditions. Surface water balance levels were consequently up to 80 mm, locally up to 120 mm, above the long-term April mean over northern Moldova, western Hungary and across much of the central and southern third of Balkan Peninsula, while central and northern Romania as well as northwestern coastal Turkey recorded surface water balance 120–160 mm above the April mean. Only northwestern parts of the region including western Slovenia and coastal Croatia recorded monthly surface water balance deficit of up to 60 mm.

AVERAGE AIR TEMPERATURE ANOMALY [°C]

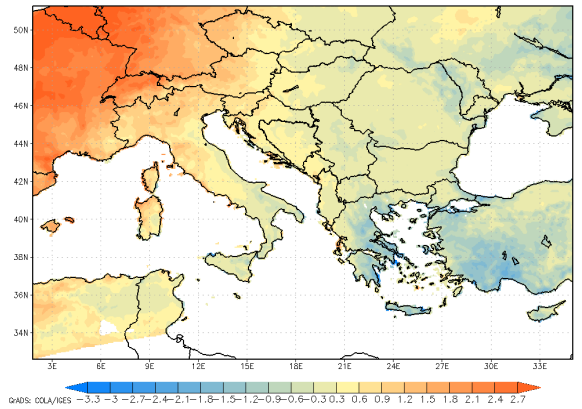
SURFACE WATER BALANCE [percentile classes]

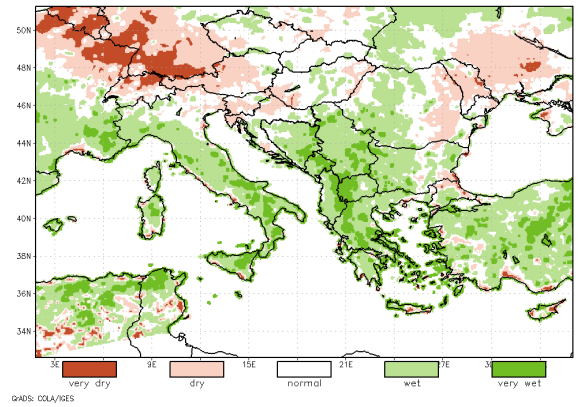
MAY 2023





JUNE 2023





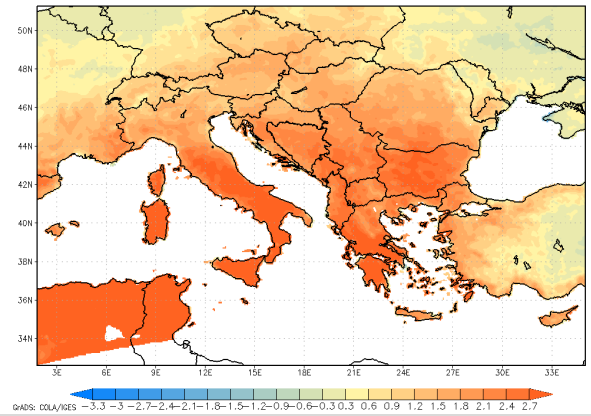
Throughout **May**, air temperatures remained normal to colder than normal across the region, with the latter persistent especially across Greece and eastern half of the region. Monthly mean air temperature was therefore more or less average across the region's northwestern half while for the rest it was another colder-than-normal month, up to 1.5 °C below the long-term May average, over the Bosporus Strait area and over much of Greece up to 2 °C lower. Precipitation level was again higher than normal, especially along the southern Adriatic Sea, Greece and western Turkey, ending a month with another 120–200 mm surplus of surface water balance. On the other hand, Romania and Moldova again experienced a drier than normal month, which resulted in monthly surface water balance deficit of 40–80 mm.

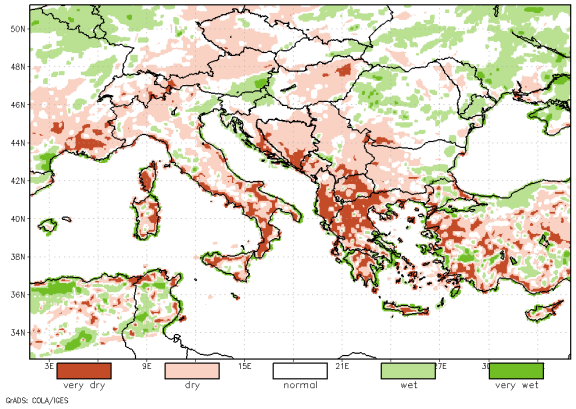
Across wider Aegean Sea area, western half of Turkey and over the region's far north-east, air temperatures remained below the average until mid-**June**, thus resulting also in June being 1.5–2 °C colder than it normally is. Only Slovenia experienced warmer-than-normal June, of up to 1 °C, mostly on the account of a warm influx of air mass in the last dekad. Monthly precipitation level was less than the long-term usual along much of the northern belt from western Croatia to Moldova, and then southward to the Bosporus Strait area, which played the major role in a monthly surface water balance deficit of 40–80 mm, over Moldova up to 100 mm. At the same time, precipitation levels were unusually high over wider central Balkan Peninsula, Greece and northern Turkey, leaving this part of the region with another 100–160 mm of surface water balance surplus.

AVERAGE AIR TEMPERATURE ANOMALY [°C]

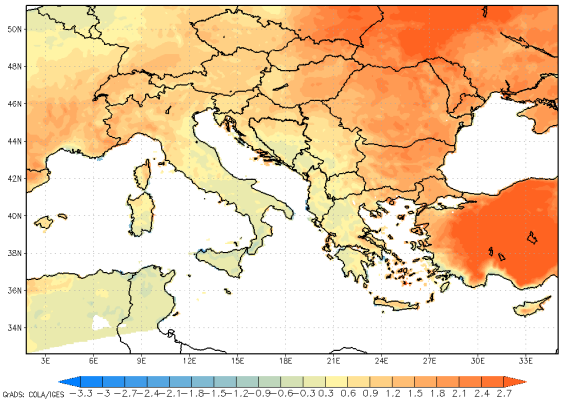
SURFACE WATER BALANCE [percentile classes]

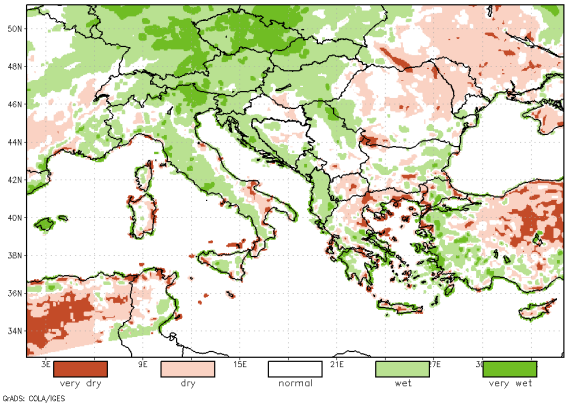
JULY 2023





AUGUST 2023





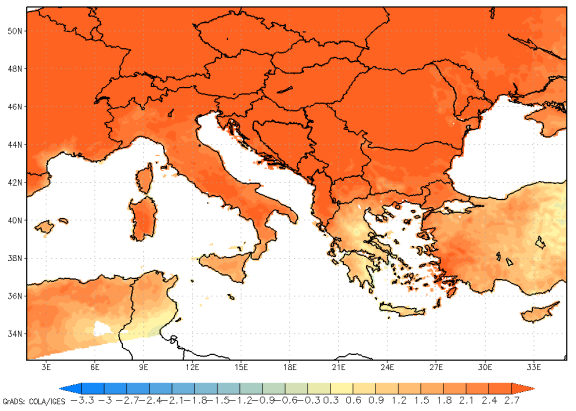
From July through to October lasted a period of mostly drier and much warmer than normal weather across the entire region, with localised exceptions. Well warmer than normal air temperature spread across Balkan Peninsula especially in mid-**July**, in Greece and Albania in last dekad of July as well. The month ended up mostly 2–3 °C warmer than normal across southern half of Balkan Peninsula including Bosnia and Herzegovina, Serbia and southern Romania, locally even more, and between 1 and 2 °C warmer across Croatia to Romania and western Turkey. The area of unusually high air temperatures to a great degree overlapped with the area experiencing lack of rain, thus creating a monthly surface water balance deficit of 60–100 mm. Although July precipitation amount was average to higher than normal across continental parts of Slovenia and Croatia, central Serbia, Romania, Moldova and much of Turkey, it was to a great degree cancelled out by higher monthly evapotranspiration upon warm air temperatures, thus leaving the area in average surface water balance levels. Only localised area in northwestern Romania and northern Turkey recorded noticeable surplus, between 60 and 120 mm.

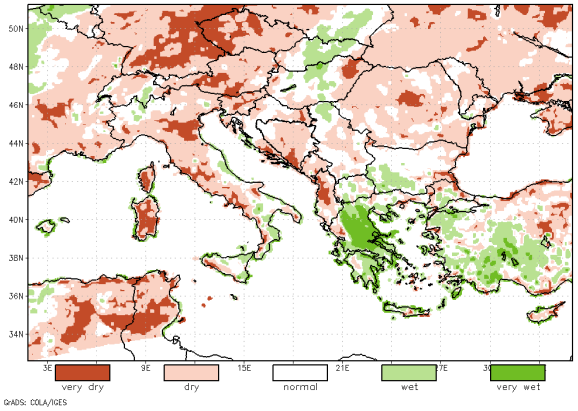
In **August**, well warmer and drier than normal weather conditions moved eastward. In Turkey and eastern half of Balkan Peninsula mean air temperature stood 2–3 °C above the long-term August average, across Turkey more than 3 °C, and together with lack of rain created a monthly surface water balance deficit of up to 80 mm. In the meantime, western parts of Balkan Peninsula up to Hungary, Serbia and Albania experienced average to slightly warmer than normal air temperatures and wetter than usual precipitation conditions this August. The resulting monthly surface water balance levels ranged about the average, while local areas across central Hungary, Slovenia, all along the Adriatic Sea area, northern Serbia and in Albania where rainfall rate was even higher, surface water balance stood 60 and 120 mm above the long-term average.

AVERAGE AIR TEMPERATURE ANOMALY [°C]

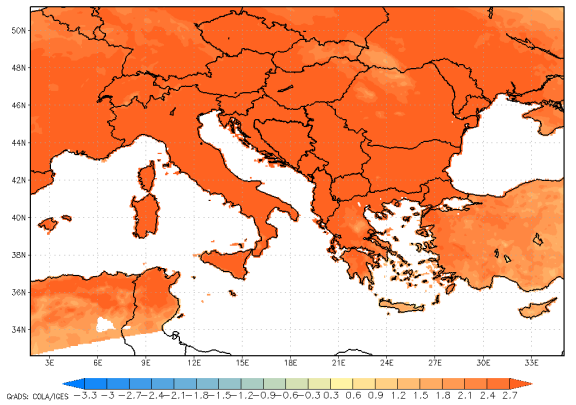
SURFACE WATER BALANCE [percentile classes]

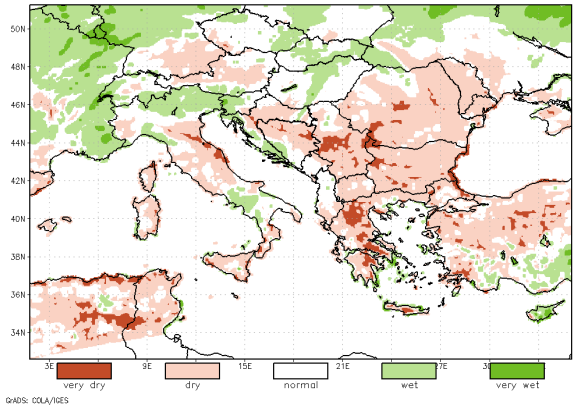
SEPTEMBER 2023





OCTOBER 2023





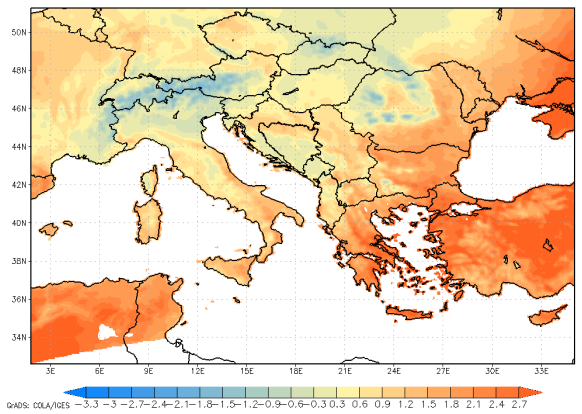
Warmer than normal weather persisted in **September**, decadal air temperature anomalies from the long-term average kept rising throughout the month, to a higher degree across the northern half of Balkan Peninsula. September was on average at least 3 °C warmer than usual across the entire region with the exception of Greece and Turkey where monthly mean was not as extreme and exceeded the average for 1.5–2 °C, along Aegean Turkey up to 3 °C. Countries in the western part of the region, from Slovenia to Albania, as well as Moldova, Romania and Black Sea coastal regions of Bulgaria and Turkey at the same time received less than normal amounts of rain, ending September with a monthly surface water balance deficit of 40–80 mm, over Slovenia and northern Albania up to 120 mm. Meanwhile, a central belt in between, from Hungary to North Macedonia but especially Greece and western Turkey received higher than normal amount of rain, which together with evapotranspiration resulted in average surface water balance levels, except for Greece that experienced an extreme rainfall rate.

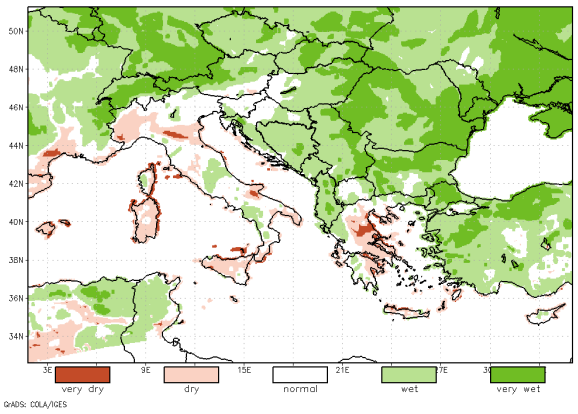
October continued with much warmer than normal weather, this time including also Greece and Turkey, which saw monthly mean of at least 3 °C above the long-term average now spread across the entire region, only in central Turkey it stood up to 2 °C higher than normal. Precipitation continued to be under-average across most of the entire region, overall bringing an additional 40–80 mm monthly deficit to surface water balance conditions. The only exception to these were Hungary and coastal Croatia with average conditions or local surplus of up to 80 mm, and especially Slovenia with locally extreme precipitation amount.

AVERAGE AIR TEMPERATURE ANOMALY [°C]

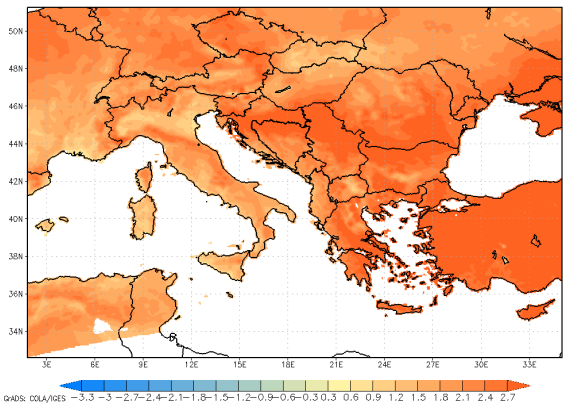
SURFACE WATER BALANCE [percentile classes]

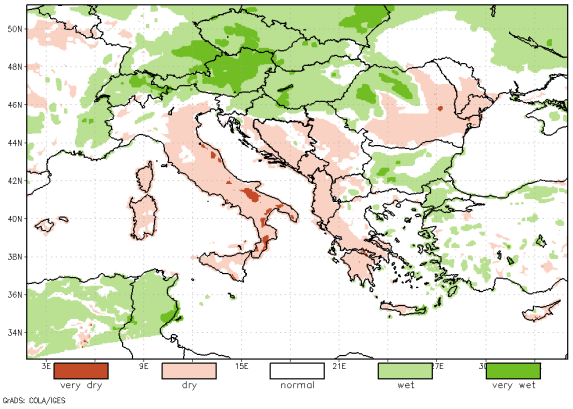
NOVEMBER 2023





DECEMBER 2023





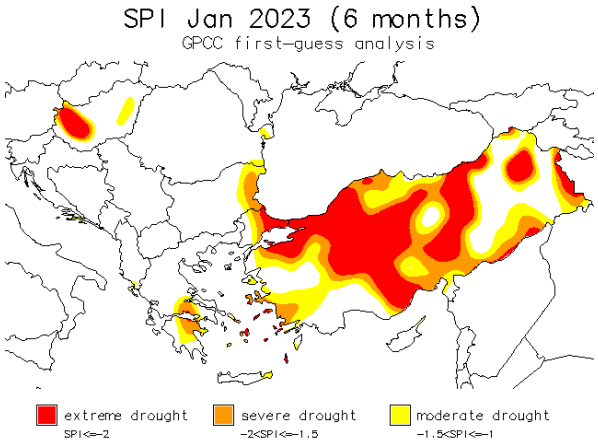
Unusually warm weather for this time of year lasted into **November** but moved eastward across the region as the month progressed, until it was gradually replaced by colder air mass over the northern Balkan Peninsula by the end of November. Monthly mean air temperature anomalies thus had a clear north-to-southeast gradient across the region. It was average or up to 1 °C colder than normal over Slovenia, across Hungary to northwestern Romania and along the Adriatic Sea, while it stood up to 2 °C above the long-term November average across the rest of the Balkan Peninsula; over the Aegean Greece and Turkey up to 3 °C warmer than normal. Central Greece received less than its usual November precipitation amount, thus recording up to 80 mm of monthly surface water balance deficit. As for the rest of the region, November ended the lasting dry period of the previous months and with the unusually high amount of rain brought monthly surface water balance surplus of 60–140 mm, especially to central Balkan Peninsula from Albania and Bosnia and Herzegovina to Moldova and northern Turkey.

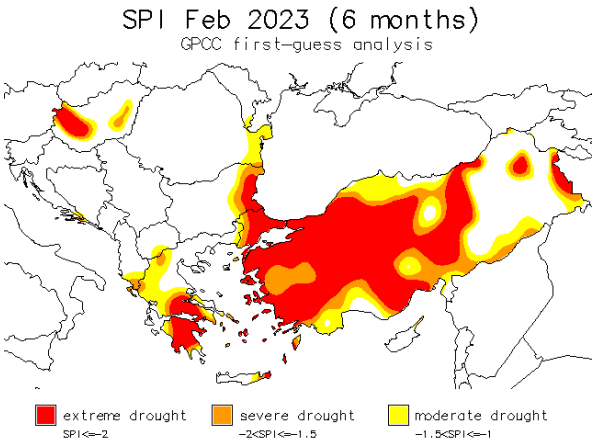
Warmer than normal air temperatures were back in **December** as nearly the entire region experienced it at least 2 °C warmer than normal, over Turkey and locally elsewhere it stood over 3 °C above the long-term average. Precipitation-wise, December was drier than normal across much of the western part of Balkan Peninsula, from coastal Croatia to Serbia and southern Greece, as well as Moldova and Romania east and south of the Carpathians, resulting in a monthly surface water balance deficit of mostly up to 60 mm, but even higher along the coastal area from southern Bosnia and Herzegovina to western Greece, between 100 and 140 mm. Elsewhere, December ended up with regular to higher than normal precipitation amount, and only localized areas across eastern Slovenia to western Hungary, northwestern Romania and southwestern Bulgaria recorded noticeable monthly surface water balance deficit, between 60 and 120 mm.

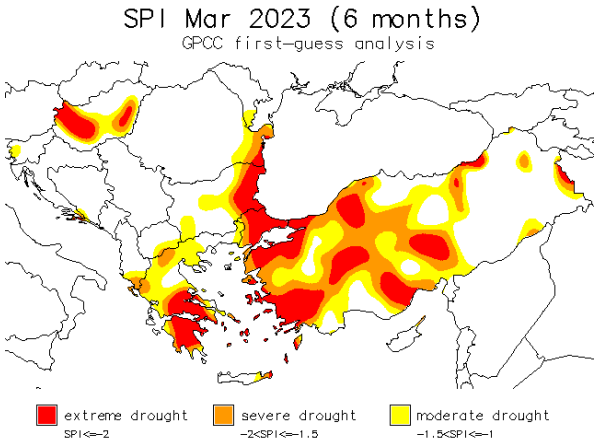
STANDARDIZED PRECIPITATION INDEX

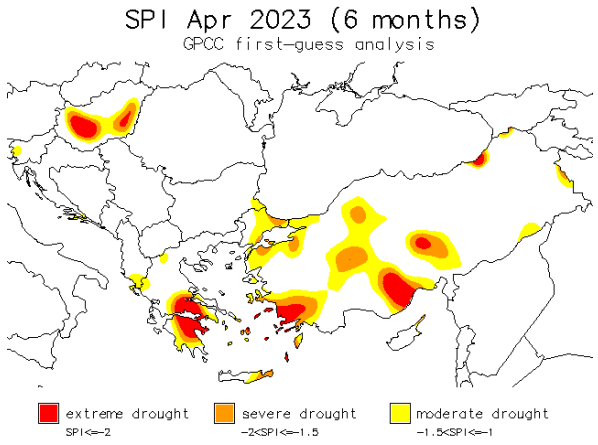
Drought situation with regard to precipitation accumulation is presented by Standardized Precipitation Index (SPI). The SPI calculation is based on distribution of precipitation over long–time period (in our case long–term average 1961–1990 was used). SPI can be calculated at various time scales which 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.

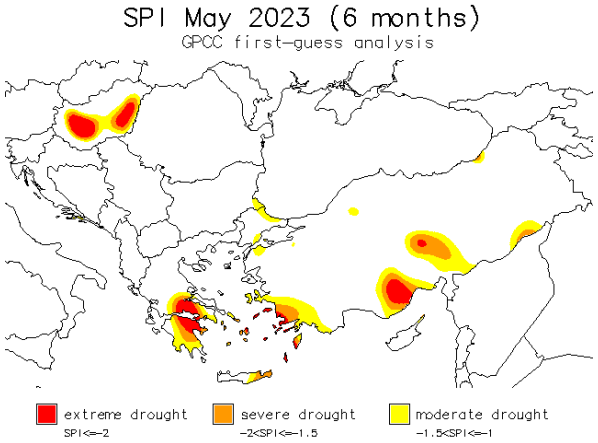
SPI maps for one and three months throughout 2023, which can be used for indication of meteorological and agricultural drought respectively, have already been published in individual monthly bulletins. Maps below show **6-monthly SPI throughout 2023**, which give indications about hydrological conditions throughout the year.

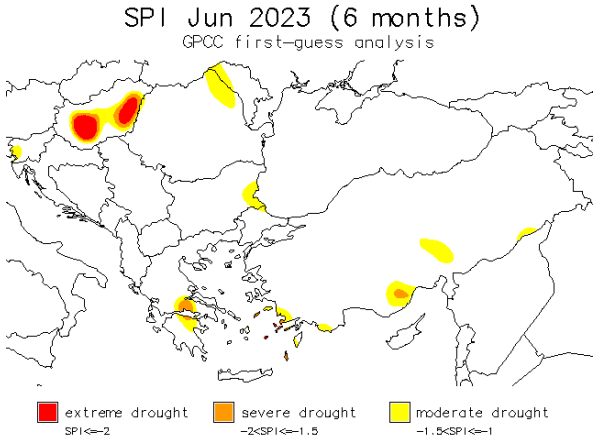


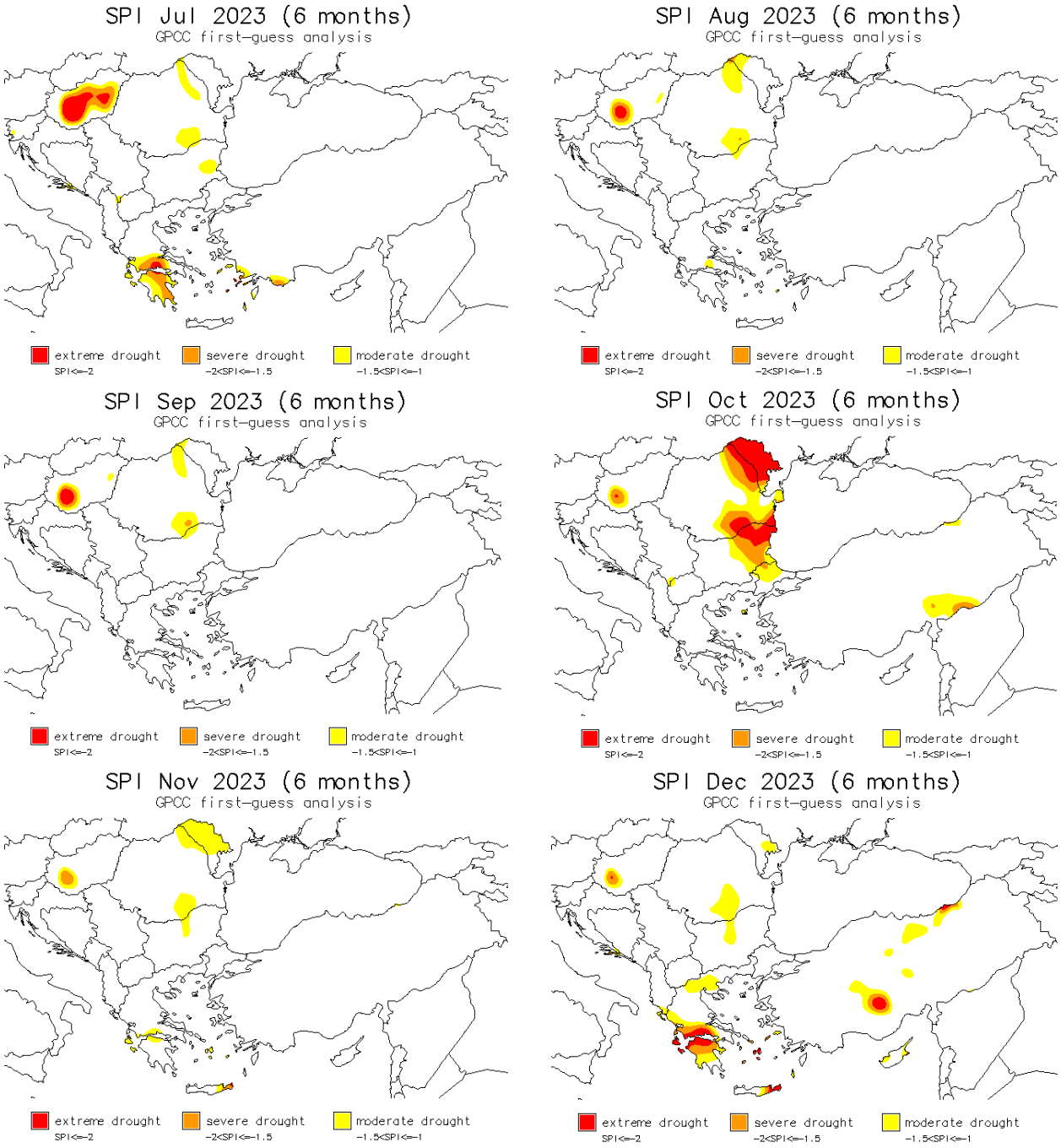












Year 2023 began on the basis of dry autumn precipitation conditions over vast part of Turkey, southern Balkan Peninsula and isolated areas across the region's north: 3-monthly SPI covering **autumn months of 2022** revealed moderate to severe lack of rain over northwestern quarter of Turkey and wider Bosporus Strait area, and noticeable deficit of a scale of extreme drought over western Hungary. As **winter 2022/23** came, dry conditions intensified across Greece and Turkey, monthly precipitation deficit reached severe to extreme level across Greece in December and February, and over all Turkey in January and February. 3-monthly SPI covering winter 2022/23 months show moderate drought conditions also across Hungary and Moldova. Altogether, it was an extremely dry 6-monthly period from September 2022 to February 2023 across a vast part of central and western Turkey, southern half of Greece, western Hungary and eastern Bulgaria.
Spring months 2023 provided with average to wet precipitation levels across nearly the entire

region, only parts of Hungary in April and northern Romania and Moldova in May experienced severe to extreme lack of rain. SPI3 and SPI6 for May reveal that precipitation level in spring months brought relief to drought conditions, as severe to extreme hydrological drought conditions ceases across much of the region and remained present only over localised areas in Hungary, central Greece and southern Turkey.

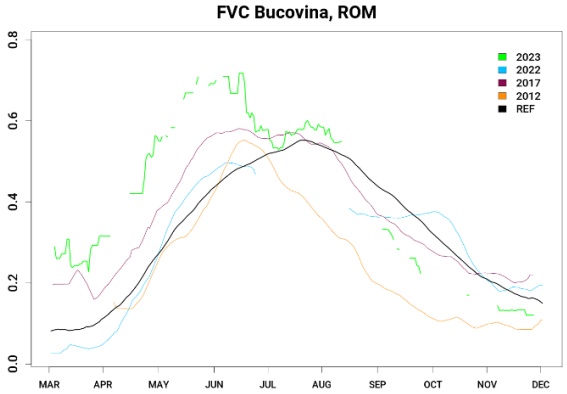
Summer months continued the spell of at least average, if not higher than normal precipitation level across much of the region, only Moldova and far eastern Romania in June as well as localised areas across northern half of Turkey and Moldova again in August recorded moderate to severe precipitation deficit. According to SPI6 for August, drought conditions in hydrological sense ceased almost entirely across the region by the end of summer, only parts of northern and southern Romania experienced moderately dry conditions, and severe to extreme precipitation deficit remained over western Hungary, but which shrank in area by the end of August.

Moderate to severe drought conditions began intensifying again in first months of **autumn**, especially in October they spread over eastern parts of Romania, Bulgaria and wider Aegean Sea area including western Turkey, while November was wet across the region with the exception of central Greece. December was extremely dry over western and southern Greece, and moderate to severe lack of rain was present over eastern Romania and central Turkey. Throughout final four months of the year, hydrological drought conditions began intensifying to moderate and severe level across localised parts of the region including Moldova, eastern and southern Romania, western Hungary and by the end of the year also over central Greece and locally in central Turkey.

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.

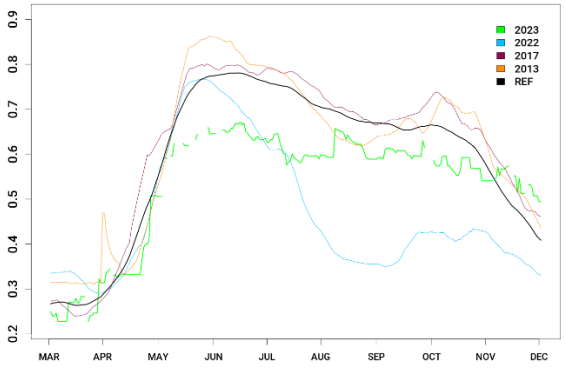
Graphs below present **vegetation development** from **March to December 2023** at 13 locations across southeastern Europe, as indicated by FVC index. FVC values for year 2023 are presented as green line. Graphs also include reference line (2004–2022) in black, and lines in light blue (year 2022), magenta (year 2017) and orange (year 2012, or 2013 for Slovenia) 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.



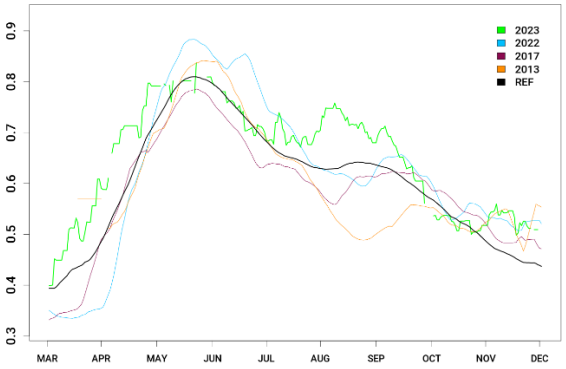
Graphs of FVC at the following locations (from top left to bottom right):

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

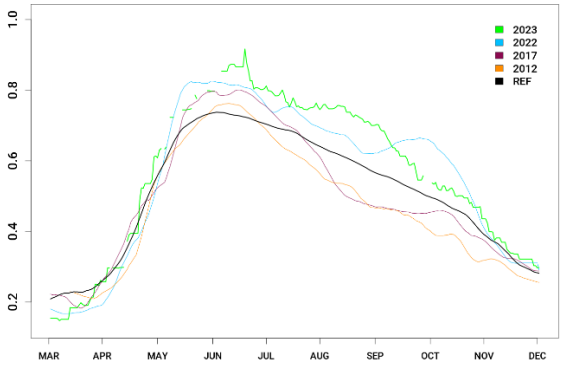
FVC Nova Gorica, SVN



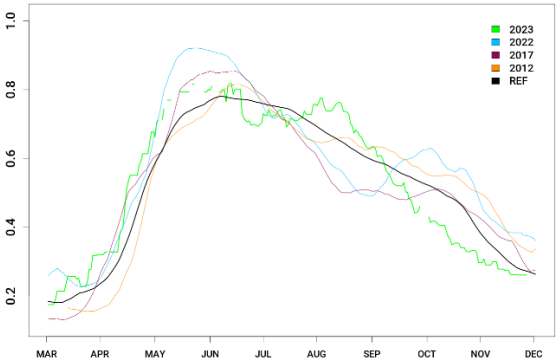
FVC Murska Sobota, SVN



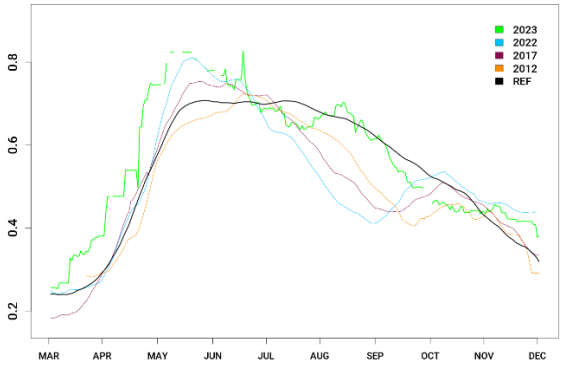
FVC Malo Orašje, SRB



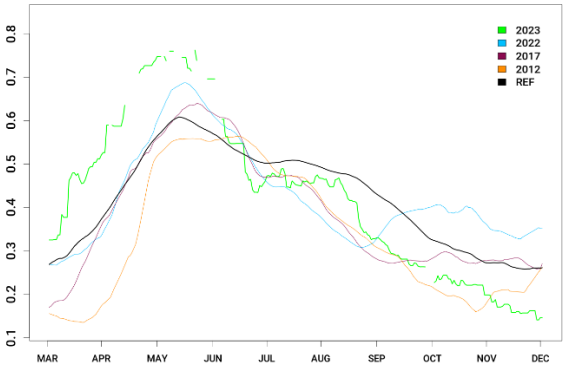
FVC Veliko Središte, SRB



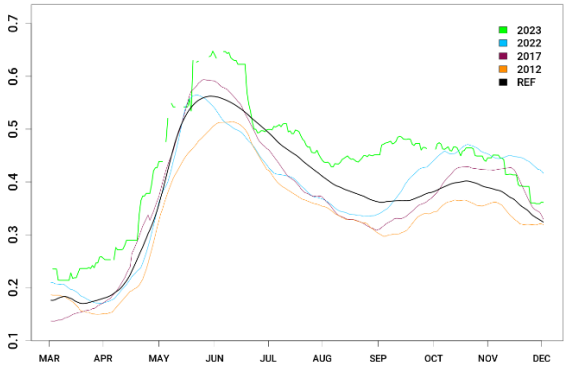
FVC Laktasi, BIH



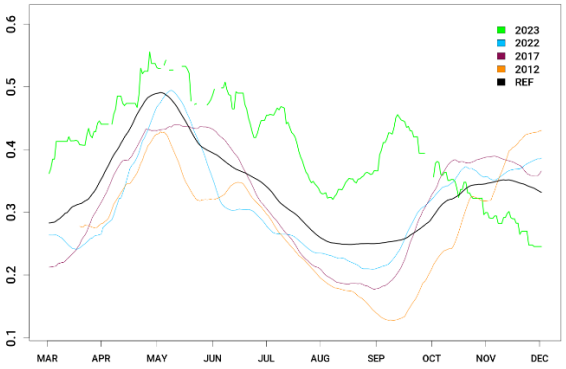
FVC Bijeljina, BIH

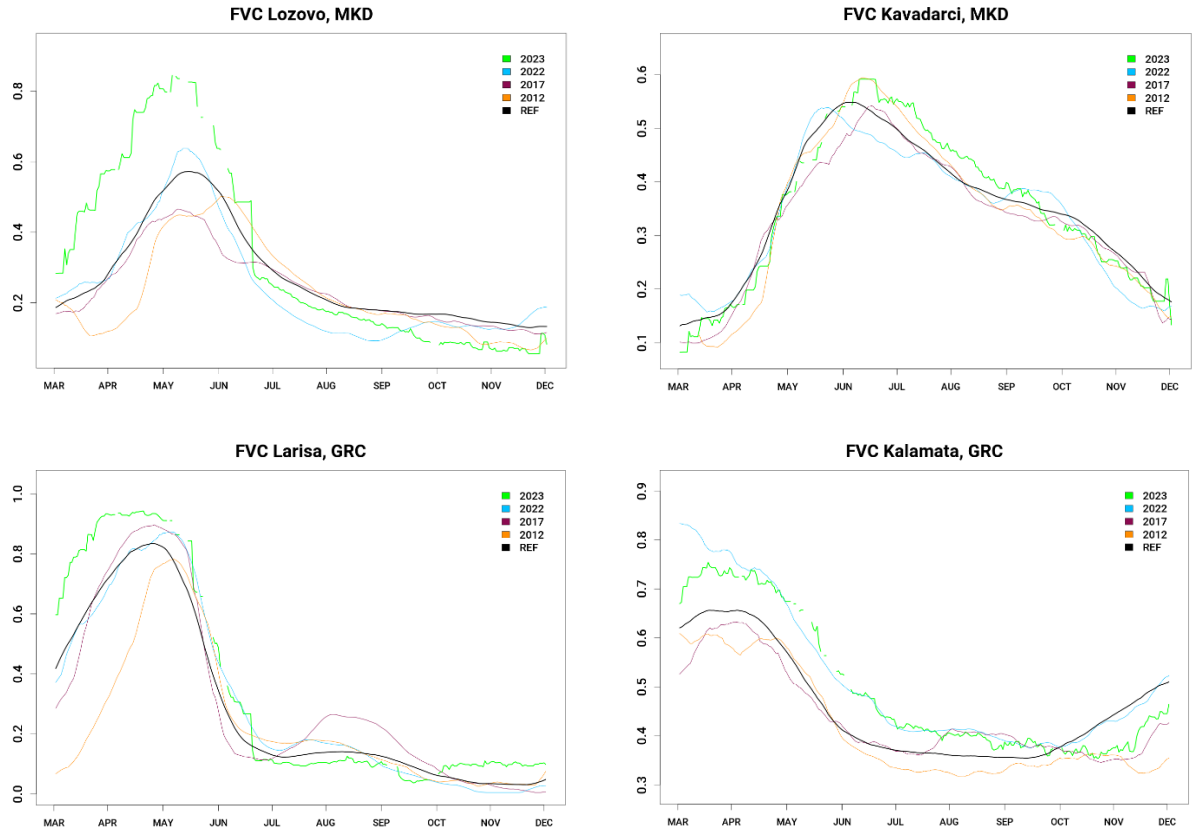


FVC Trebinje, BIH



FVC Podgorica, MNE





IMPACT REPORTS

HUNGARY

In early March, water level of the Lake Balaton was too low to allow opening of the Sio Lock, thereby making the canal navigable and providing **waterways for ships**, according to the National Directorate General of Water Resources [1]. Due to poor weather conditions, **development of corn grain** was affected across the Great Plain this year. Sowing began late this year due to cooler than average April and soil temperature only slowly reaching the 10-degree thresholds. Then from mid-April onward, soil moisture was deficient across much of the Great Plain due to lack of precipitation, and by July drought conditions were present across the Great Plain, eastern Hungary as well as over northern and southeastern regions of Transdanubia, western half of Hungary, according to the National Meteorological Service reports [2]. Water level of the Danube River dropped close to a historic low in October: in a significant part of its Hungarian section it was only a few 10 cm above the lowest value ever measured. According to the National Directorate General of Water, water level of the Danube River was less than one meter at all major domestic measuring points, similarly also at several points in the domestic section of the Tisza River, running through eastern half of Hungary. Extremely low water levels caused problems in many economic segments, including **energy production and supply** as several important power plants rely on cooling water from the Danube, but it also adversely affected **river freight transport, drinking water supply, agriculture and tourism** [3].

[1] https://nepszava.hu/3187378_bahart-hajozas-balaton-alacsony-vizszint
[2] https://index.hu/belfold/2023/07/21/alfold-eso-kukorica-aszaly-idojaras-orszagos-meteorologiai-szolgalat-mezogazdasag/
[3] https://index.hu/belfold/2023/10/19/duna-apadas-tortenelmi-melypont-vizallas-rekordalacsony-vizugyi-foigazgatosag-europai-aszaly-klimavaltozas/

CROATIA

In September, the weather was extremely warm across almost the entire country compared to the average, and was accompanied by the absence of rain, meaning the amount of precipitation was below the average at almost all meteorological stations. Drought conditions were mostly felt in the Kvarner Islands and in parts of Istria, northern, central, eastern, and southern Croatia. Considering that the green biomass of corn was visible in the fields almost until mid-September, drought and extreme temperatures accelerated the **ripening and drying of the corn ears**.

Extracted from:
https://meteo.hr/klima.php?section=klima_pracenje&param=spi&el=prspi
https://meteo.hr/klima.php?section=klima_pracenje&param=ocjena
https://meteo.hr/proizvodi.php?section=publikacije&param=publikacije_publikacije_dhmz&el=bilteni
https://meteo.hr/klima.php?section=klima_pracenje&param=spi&el=karte_suse&Week=231012

MOLDOVA

Several areas in northern Moldova reported of very scarce precipitation since April, leading to **drying up of the crops** as well as the soil by June, which at some places already began forming cracks of more than 5 cm in depth. Corn, sunflower and sugar beet were at that time at the beginning of the growing season, thus further lack of rain posed a threat to affect later yield [1].

[1] https://www.publika.md/video-nordul-moldovei-este-afectat-de-seceta-locuitorii-se-plang-pe-lipsa-precipitatiilor_3137434.html

ROMANIA

While in May, some parts of the country experienced heavy rains and floods that swept away hundreds of hectares of cultivated land, other parts of Romania faced lack of soil moisture, eventually leading to topsoil drought conditions. In some counties along the southern Romania, such as Campia Baraganului, Calarasi or Braila, agricultural crops were already observed suffering negative impacts due to the lack of rain. According to the League of Associations of Agricultural Producers from Romania, under drought stress were mostly **autumn crops** but also **those sown in spring** [1]. In June, farmers from several counties already complained of drought impacts on both autumn and spring crops, which were in June in greatest need for water while precipitation was scarce. According to the National Meteorological Administration, moisture content of the soil indicated moderate and strong pedological drought in regions of Dobrogea, on extensive areas of Moldova and Muntenia, locally in the south and center of Transylvania, and isolated in the northwest of Banat region, southwestern Romania [2]. According to the European Commission estimates done in September, Romania experienced the weakest year in the last five years in **sunflower production**. Harvest was decreased by a third compared to the previous year, and the quality of sunflower seeds was also poor. High air temperature at the beginning of autumn acted as an additional unfavourable factor. In Iasi County, northeastern Romania some farmers ended up with 30 % of production compromised and were unable to cover the expenses. Low production and poor seed quality would further affect **oil industry** [3].
By late October, entire northwestern half of the country was under pedological drought, according to the National Meteorological Administration, and made land extremely dry in many areas to great depths, jeopardizing **sowing autumn grain** such as wheat and barley. Local farmers from Bistrita-Nasaud County, northern Romania reported of having to use large and powerful tractors for ploughing and till the soil twice to break up the rock-hard clods. To those

successful in sowing grains, lack of soil moisture provided further threat as hindered grain sprouting [4, 5]. Also affected was **harvesting potatoes.** In Covasna, central Romania, rock-hard dry land prevented farmers from collecting potato yield without first watering the furrows [2]. Due to well-above-average high temperatures, which some places reached up to 30 °C, fruit trees in some orchards bloomed for the second time in the year, which could affect next year's fruit production [4]. In late October, the **Danube River almost dried up** at Bechet, southern Romania. Its water level dropped so much large sand dunes were formed in many parts of the river, consequently making Danube unsuitable for **ferry crossing**. Bechet Broder Crossing was closed as the ferry could no longer cross the Danube from the Bulgarian side, and trucks full of goods had to shift to Calafat, southwestern Romania, some 100 km upstream to cross the river, where water level was at least acceptable and safe for traffic between the banks. This poor river level situation created kilometers long queue in **lorry traffic** before they could continue the journey [6].

[1] https://agrointel.ro/260617/anul-agricol-la-extreme-nina-gheorghita/
[2] https://agrointel.ro/262750/romania-maturata-de-ploi-judete-intregi-raman-insa-afectate-de-seceta-harta-anm/
[3] https://stirileprotv.ro/stiri/actualitate/culturile-de-floarea-soarelui-distruse-de-seceta-cea-mai-slaba-productie-din-ultimii-cinci-ani.html
[4] https://stirileprotv.ro/stiri/actualitate/vremea-calda-pune-productia-de-cereale-de-anul-viitor-in-pericol-nu-se-poate-ara-se-distrug-plugurile.html
[5] https://stirileprotv.ro/stiri/actualitate/zsuntem-disperati-pentru-ca-nu-putem-infiinta-culturi-de-toamna-seceta-a-afectat-mai-bine-de-jumatate-din-tara.html
[6] https://stirileprotv.ro/stiri/actualitate/dunarea-aproape-a-secat-iar-bacul-nu-mai-poate-trece-pe-la-bechet-barcile-esueaza-pe-dunele-de-nisip-in-mijlocul-fluviului.html

BULGARIA

In mid-June, **drinking water resources** in Yambolsko region, eastern Bulgaria was drastically reduced and several villages were on the brick of introducing a water regime. The problem was particularly serious in villages of Drama, Miladinovtsi and Krumovo whose wells are fed by the Kalnitsa River, but which in mid-June was almost dry. Similar situation was present in villages of Lyulin and Nedyalsko, whose water resources had its flow rate halved. A lack of sufficient water resources was reported also for the village of Boyadzhik. Low water levels in their reservoirs posed a threat to **fish dying** and low groundwater levels allowed insufficient irrigation of **vegetables and fruits**, which at that time were at their ripening stage [1]. In august, farmers in the Rasgrad region, northeastern bulgaria reported of poor state of health of spring crops, mostly **sunflowers and corn**, due to precipitation deficit, lack of soil moisture and high air temperatures. As of the end of August, a large part of corn did not form cobs [2]. Water reservoirs in wider Yambol region were again very low in October, this time **endangering water supply** in municipalities of municipalities of Elhovo, Tundzha, Straldzha and Bolyarovo. Water supply problems continue also in Tundzha municipality, encircling Yambol, where four villages were reported without water - Savino, Mogila, Chargan and Ovchi Kladenets [3, 4].
According to the data of Regional Directorate Agriculture issued in mid-October, 8189.3 decares of corn areas in Dobrich region, northeastern Bulgaria were lost due to drought [5]. According to a joint inspection of the Forest Protection Station Varna and the Regional Forestry Directorate Varna, autumn drought began **mowing down cherry plantations** in the municipality of Tervel, northeastern Bulgaria. The health problem was found in both seed and shoot plantations, regardless of age [6]. Severe autumn drought in Dobrudja region, northeastern Bulgaria heavily **affected sowing of autumn grain**. After extremely low average yields of **sunflower and maize**, farmers were faced also with the difficulties ploughing the fields to sow wheat, barley and rapeseed. Massive machinery breakdowns, extreme dustiness that further complicates the process, lack of any moisture at a meter depth and high temperatures are among the main problems of this year's autumn agricultural campaign [7].

[1] https://www.actualno.com/yambol/drastichno-namaljava-debityt-na-pitejnite-vodoiztochnici-v-jambolsko-news_1995127.html
[2] https://www.bta.bg/bg/news/bulgaria/512274-po-niski-dobivi-ot-tsarevitsa-i-slanchogled-ochakvat-zemedeltsite-v-razgradsko

[3] https://www.dnes.bg/stranata/2023/10/24/tejka-susha-v-iambolsko-chetiri-obshtini-sa-pred-voden-rejim.586918
[4] https://www.bta.bg/bg/news/bulgaria/534344-prodalzhavat-problemite-s-vodopodavaneto-v-obshtina-tundzha-chetiri-sela-sa-bez
[5] https://www.bta.bg/bg/news/economy/542530-nad-8-hilyadi-dka-sa-povredenite-ploshti-sas-zemedelski-kulturi-v-oblast-dobrich
[6] https://www.bta.bg/bg/news/economy/541933-sushata-pokosyava-tserovi-nasazhdeniya-v-obshtina-tervel-saobshtavat-eksperti
[7] https://www.dnes.bg/stranata/2023/10/27/tejka-susha-v-dobrudja-na-mesta-ne-e-valialo-ot-iuni.587305

GREECE

In July, Greece experienced remarkable hot-dry-windy weather conditions. As a result, **forest fires** occurred in many areas, with the most disastrous in the island of Rhodes (SE Greece), the island of Kerkyra (NW Greece), in Karystos (Evia), in Magnesia (central Greece), in Couvara (Attica), in Loutraki (NE Peloponnese) and Viotia (central Greece). Based on Copernicus data, almost 500,000 acres were burnt in Greece in July. The island of Rhodes is counting more than 175,000 burnt acres, while areas in Attica, Magnesia, Loutraki and Viotia were also severely damaged [1,4]. According to CAMS, between July 1 and July 25, gas emissions reached 1 megaton of carbon. This is a 21-year record level, almost double the previous record, which referred to the same period in 2007. This figure is equivalent to the pollution produced by 222,500 cars in a year [2, 3]. The hot-dry-windy weather conditions of July 2023 continued also in August. Major fires occurred in western Attica close to Athens, but especially in Alexandroupoli-Evros and the Dadia Forest National Park, where the individual fires formed a mega-fire in the northeastern Greece. An analysis of high-resolution images of the Sentinel-2 shows that more than 5000 ha were burnt by 22 August 2023 in Fyli, western Attica [5]. The fire in Evros caused severe damage with **losses in livestock and arable land**. According to Hellenic Agricultural Insurance Organization, until 21 August 2023, 1.200 beehives and hives had been burnt in a total of 26.264 and 910 small animals were charred, the majority of them being goats and sheep [6]. In the Dadia Forest National Park, one of the most important **protected areas** at the international, European and national levels, the disastrous fire that broke out for a second consecutive year poses a direct threat to the unique ecosystem, especially to the black grouse colony [7, 8]. Until 28 August 2023, over 82.600 ha were burned in Evros [9]. It is the largest fire in the EU since 2000 when European Forest Fire Information System started recording data, and as of the end of August it was ongoing for the 13th day [10, 11].

[1] https://gr.euronews.com/2023/07/30/ellada-karboyno-ton-ioylio-panw-apo-miso-ekatommyrio-stremmata
[2] https://www.kathimerini.gr/life/environment/562539652/copernicus-gia-ellada-se-ypsilo-21-eton-oi-ekpompes-aerion-apo-tis-foties/
[3] https://www.tovima.gr/2023/08/04/stiles/sok-ton-ioulio-kaike-stin-ellada-ektasi-megalyteri-apo-to-londino/
[4] https://gr.euronews.com/2023/07/17/greece-heatwave-update
[5]https://www.real.gr/koinonia/arthro/perissotera_apo_617_000_stremmata_katekapse_mexri_simera_h_pyrkagia_ston_ebro_kai_pano_apo_50_000_sti_fyli_attikis-943467/
[6] https://www.newsit.gr/ellada/fotia-stin-aleksandroupoli-anypologistes-oi-katastrofes-apanthrakothikan-910-zoa-terastia-zimia-se-ypodomes/3843496/
[7] https://www.enikos.gr/society/evros-fotia-sto-dasos-tis-dadias-apeileitai-amesa-i-apoikia-tou-mavrogypa-foto/2015068/
[8] https://www.tanea.gr/2023/08/23/greece/dasos-dadias-poios-einai-o-perivallontikos-thisayros-pou-paradothike-stis-floges/
[9] https://www.ertnews.gr/featured/evros-nea-112-se-sidiro-kai-giannouli-gia-isxyres-anazopyroseis-tragiki-i-katastasi-se-kotronia/
[10] https://www.tanea.gr/2023/08/29/greece/komision-oi-megalyteres-dasikes-pyrkagies-pou-exoun-katagrafei-pote-stin-ee-aytes-stin-ellada/
[11] https://www.ertnews.gr/eidiseis/ellada/anekselegkta-pyrina-metopa-ston-evro-proliptiki-ekkenosi-tis-perioxis-aspropoulia-stin-kalamata-apo-to-112/

TURKEY

Due to precipitation deficit throughout winter season 2022/23, drought problems arose across vast part of the country. According to the General Directorate of Meteorology, Turkey experienced the driest January in the last 22 years [1, 2]. Such conditions at this time of year caused **hydrological drought**, as water levels in rivers, dams and ponds dropped drastically, and less **snow cover** was present in the mountainous area. Much reduced or even absent was snow cover in Mount Nemrut in Adiyaman, southeastern Turkey as well as in Spil Mountain in Manisa, western Turkey, both of which are popular tourist destinations [3]. In December 2022 already, Bayramic Dam in far western Turkey, which has a water capacity of 96.5 million cubic meters, had only about 10 million cubic meters of water left due to drought. With decreased water level

of the dam, the ruins emerged of a 1,500-year-old bath and church belonging to the ancient city of Skepsis [4].

In January, islets appeared in Turkey's **longest river** Kizilirmak near Yahsihan, central Turkey [5]. Drought also hit Lake Iznik in the country's north-west, one of the country's **largest fresh water resources**. Water receded 400 meters from its original shore and the pier remained well on land, reaching alarming proportions due to winter drought [6]. As a result of lack of rainfall and absence of snowfall, also in Sapanca Lake, northwestern Turkey water level dropped significantly and receded from its original shore line for about 40 meters. It rose concerns over the drinking water supply as water from this lake normally meets 90 % of Sakarya's drinking water needs and 15 % of Kocaeli's water needs [7]. Severe concerns arose in January over **drinking water supply also for Istanbul**, Turkey's most populous city, as the average of the occupancy rates of the dams supplying Istanbul steadily declined every month from nearly 90 % in March 2022 down to 30 % at the end of January 2023, the lowest there has been in the last 10 years. Of the dams supplying Istanbul, the worst situation was at Pabucdere Dam and Kazandere Dam with water levels at less than 5 % their full capacity. According to the University Geographic Information Systems and Remote Sensing Center, this meant that Istanbul residents had 15 cubic meters of water left per person, or enough to meet Istanbul's water needs for only two more months [8, 9, 10, 11]. In the Black Sea region, known for regular precipitations, the lack of precipitation triggered concerns also over **groundwater** levels [11].

In February, low water levels in dams triggered **drinking water supply** concerns also across wider northwestern and wester part of the country, especially those supplying **Bursa, Odrin and Izmir** cities. Of the two dams supplying Bursa, Nilufer Dam with its annual capacity of 60 million cubic meters and stretching over 1.47 square kilometres completely dried up and the occupancy rate of Dogancı Dam positioned in the lower basin from Nilufer Dam stood at 24 %, the lowest level since its establishment in 1983 [12, 13, 14]. Similar situation was observed in Odrin region, northwestern Turkey, where much reduced occupancy rate of the Kadikoy Dam, which meets most of the water needs of Kesan district, could meet water needs of Kesan for a maximum of 3–4 month [15]. By the end of February, water level in Kozan Dam in southern Turkey also dropped to 28 % and islets formed on its banks. **No dam irrigation** was allowed, posing great concern to farmers whose planting season already began. Warmer than normal weather as well as dry soil affected root growth in wheat and barley, indicating potential for decreased yield, similarly as reported also from Trakya Seeds Association, northwestern Turkey [16, 17, 18].

Hydrological drought upon the driest winter season of recent years continued to cause problems also in March. The occupancy rate of the Cekerek Dam, central Turkey, which normally irrigates 66,165 hectares of land in Yozgat, Corum, Amasya and Tokat, decreased to mere 10.6 %. **Water shortages** were reported also in Mersin, Mediterranean Turkey where water level in Berdan Dam, which supplies the city with water for both drinking and agricultural irrigation purposes, droped to 15 %. With water level at such critical state, it was no longer allowed to be used for **agricultural irrigation** [1, 19]. In Buyukcekmece Lake, northwestern Turkey, water was visibly withdrawn, the lake partially completely dried up and islets were formed at some parts of the lake. According to the fishermen, water level which at certain plances used to stand at 5-6 meters, in early March stood at 2-2.5 meters, and pointed out the situation was critical also for **fish community** [20]. By mid-March, water level of many dams across Turkey fell to the lowest level in recent years due to drought. According to the Canakkale Municipality, western Turkey, water level in Atikhisar Dam which meets the drinking use and agricultural irrigation needs of the city, decreased by more than half. **Water restrictions** and bans put in place were directed at both household use as well as its use in industry and services, introducing maximum limit of water consumption per month and prepaid electronic meters to be installed in workplaces with high water consumption, such as car and carpet washing, Turkish bath and toilet. It became obligatory

for places using groundwater to install mechanical meters for determining groundwater use, and use of water for agricultural purposes were limited to urgent irrigation only [21, 22]. Pointed out by the University Maritime Faculty Dean, there was increased risk of **mucilage in Marmara Sea** as a result of drought reducing the inflow of fresh water from the inland, but also due to increased sea surface temperature, which in late March was measured 4 °C higher than in March of previous year [23].

As of the end of May and early June, **water levels in dams supplying Istanbul** remained low to very low, ranging mostly from up to 50 % for Omerli and Darlik dams to as low as 4 % of their full occupancy rate in Pabucdere and Kazandere dams [24, 25]. During summer months, water level in Kozan dam supplying Adana city, southern Turkey kept receding and dropped to 33 % in mid-July, forming islets across the dam catchment [26]. In late August, the average occupancy rate also of dams supplying Istanbul fell to 32 %, the lowest in last 9 years, and declining further on throughout September, to an average of only 25 % [27]. Sheep were seen grazing in places that water used to occupy in the past [28, 29]. At that time, **mass fish deaths** were observed in the Buyuk Menderes River, western Turkey due to drought and extreme heat. Hundreds of fish, along with other aquatic creatures died near town of Sarikemer Taskopru [30, 31]. Due to extreme heat and drought in Edirne region, far northwestern Turkey, there was a significant decrease in **honey production** compared to last year. As drought that started in winter months continued with extreme heat in the summer months, bees could not collect the desired nectar and pollen from the dried flowers. The President of Edirne Beekeepers Association stated that production losses in 2023 were about 60 % around Edirne region and throughout Thrace [32]. According to Trakya Birlik Board of Directors, drought and hot weather decreased both yield and quality of **sunflower production** in the Edirne and Thrace regions, an important sunflower production centres in Turkey, further affecting **sunflower oil production**. Yield losses varied regionally, ranging from 25 % to 75 %, while in some fields harvest was even impossible to be made due to the failure of plant development [33, 34, 35].

In autumn, **many ponds, dams and waterfalls** in Kirklareli, northwestern Turkey were also affected by drought, after first experiencing lack of rain in the spring and scorching heat in summer months. Some of the waterfalls, many of which occur naturally in forest areas, dried up due to the drought [36]. By October, **water levels** in Seyham Dam Lake in Adana region decreased so much that a part of ancient city of Augusta from the Roman period surfaced above the low water level [37]. The flow rate of Meric and Tunca rivers passing through Edirne city were in late autumn at the bottom level, and sand islands were seen formed on the rivers [38, 39]. The **saffron harvest** in Karabuk, northern Turkey, was also expected to be low due to the dry season [40]. Prolonged drought affected **water reservoirs** also in southwestern Turkey. Water level in the Mumcular dam, which feeds Bodrum city, one of the biggest cities in that part of the country, remained very low compared to previous years due to the drought and accompanied with increased water use in recent years dropped to around 8 %, thus the dam was closed and water transmission was interrupted [41].

[1] https://www.hurriyet.com.tr/gundem/kurak-havalar-sonrasi-su-alarmi-barajlardaki-seviye-azaldi-42227294
[2] https://www.aksam.com.tr/guncel/istanbulda-barajlarkritik-seviyede-son-22-yilin-enkurak-ocak-ayi/haber-1345763
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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 having a 5-percent range and each of the middle three classes having 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 2022). Information on drought impacts are obtained from freely available online reports of national authorities and media newspapers.