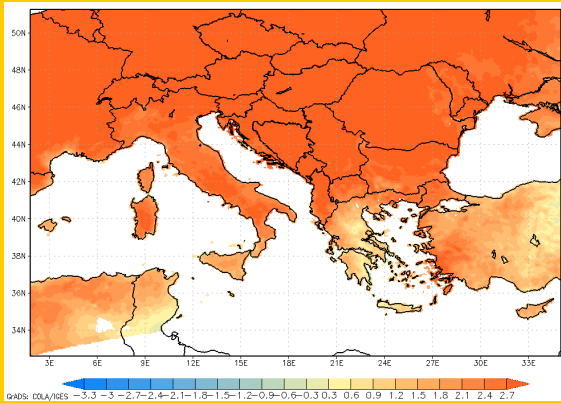


DROUGHT MONITORING BULLETIN

September 2023

HOT SPOT

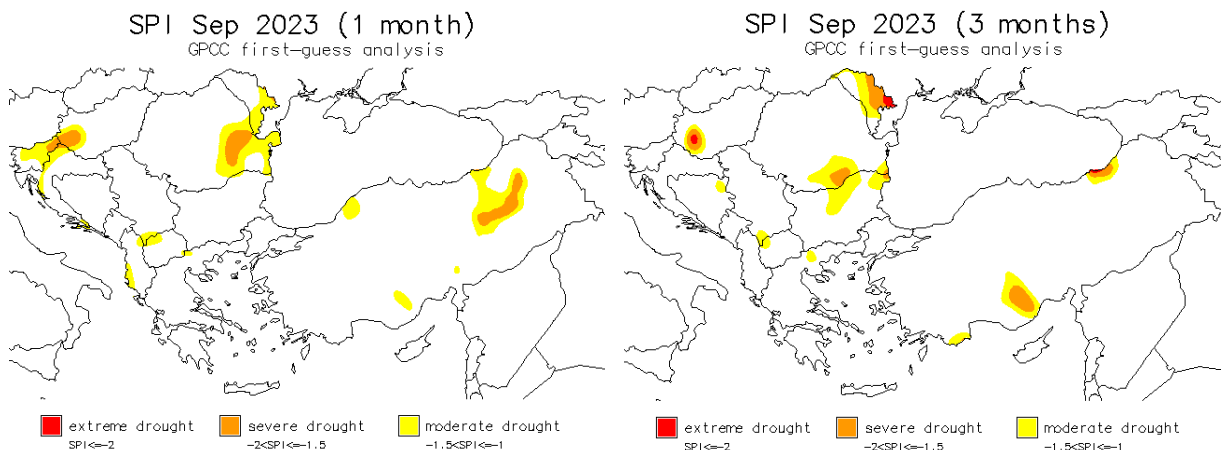


This September was one of the hottest of the long-term record across much of northern and western Balkan Peninsula. In many places, daily air temperatures exceeded 30 °C, locally even in late September. As seen on the figure showing **anomaly of September mean air temperature** in comparison to 1991–2020, September was at least 3 °C warmer than usual across a vast part of the region. Mean air temperature was closer to the average only in central Turkey and in central and southern Greece, aligning with the area of heavy rain.

STANDARDIZED PRECIPITATION INDEX

Drought situation with regard to the precipitation level is presented by Standardized Precipitation Index (SPI). The SPI calculation is based on the distribution of precipitation over long time periods (at least 30 years) and can be calculated at various time scales that reflect the impact of drought on the availability of water resources. The long-term precipitation record is fit to a probability distribution, which is then normalised so that the mean (average) SPI for any place and time period is zero. SPI values above zero indicate wetter periods and values less than zero indicate drier periods. Only the dry part of the extreme anomalies is presented on the maps.

Standardized precipitation index for **September 2023** is shown in figures below. SPI for a one-month period indicates possible drought conditions which can have impact on vegetation, while SPI for a three-month period can be indicative also for surface water status.



In terms of precipitation deficit, various localised parts of the region recorded lack of rain of a moderate extent. These included eastern half of Slovenia, southeastern Albania, northern parts of North Macedonia, southeastern Romania and Moldova as well as localised areas in the northern and southern Turkey. Even greater lack of rain corresponding to severe drought conditions was experienced in border area across Slovenia and Hungary, in the southeastern Romania and in the eastern third of Turkey.

A 3-monthly precipitation accumulation indicates that July to September period was generally not dry across most the region except over some localised parts of it. Accumulated lack of rain in this 3-month period would classify as moderate in smaller parts of North Macedonia, southwestern Serbia, eastern Bosnia and Herzegovina and southwestern Turkey, mostly on the account of dry September, as well as across northern Bulgaria as a result of accumulated lack of rain experienced in July and August. SPI3 shows that July to September period was severely to extremely dry across much of eastern half of Moldova and over localised areas in southern Romania, southwestern Hungary and in parts of southwestern and northeastern Turkey, mostly as a result of drier than normal July and August.

AIR TEMPERATURE AND SURFACE WATER BALANCE

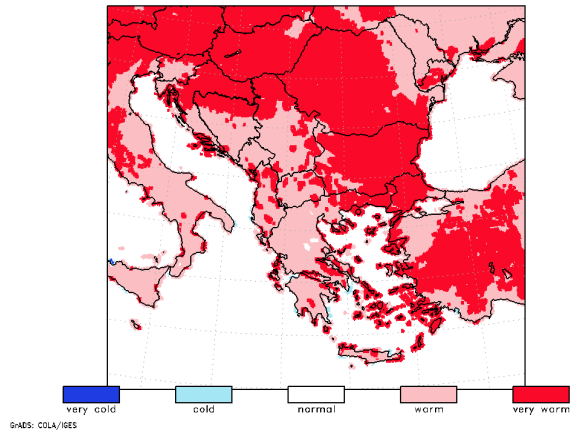
Figures in this section show anomalies of the *mean air temperature* and *accumulated surface water balance* as well as their absolute values classified in percentile classes for the 60-day period *between 30 July and 27 September 2023*.

AVERAGE AIR TEMPERATURE
ANOMALY (°C)
30 JULY – 27 SEPTEMBER 2023



GHAE: COLA/ISES

AVERAGE AIR TEMPERATURE
PERCENTILE CLASSES
30 JULY – 27 SEPTEMBER 2023

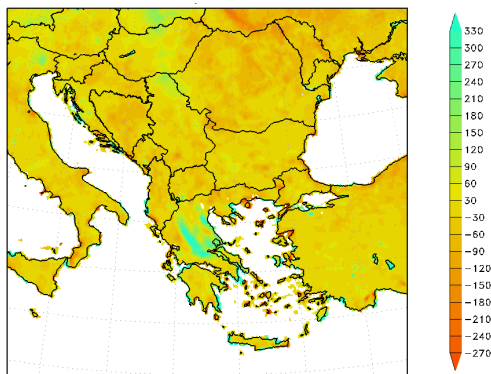


GHAE: COLA/ISES

First of the autumn months was unusually warm across much of the region. Air temperature were more or less average only in first days of September across western half of Balkan Peninsula and in mid-month days over central Turkey. During early September, areas along the Black Sea experienced air temperatures up to 4 °C warmer than normal, with a decreasing gradient in westward direction where normal air temperature prevailed. In mid-September, warm air mass came in to the region from the north-west, resulting in mid-September days being 3–5 °C warmer than usual in greater northwestern quarter, from northern Romania to Montenegro, while also the rest of the region was up to 3 °C warmer than normal for this time of year, with the exception of central and southern Greece in average air temperatures and central Turkey in up to 2 °C colder air temperatures. Before the end of the month, warm air

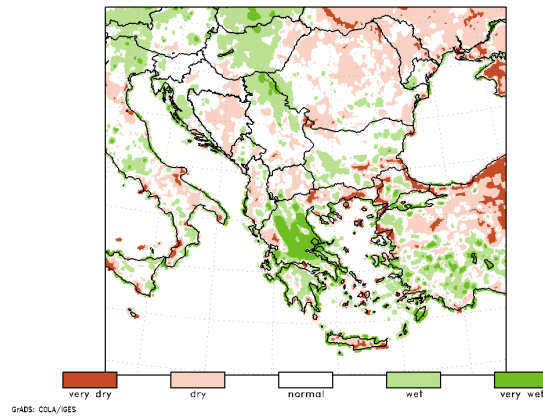
mass spread across the entire region and resulted in one of the hottest end of September in last decades. Anomalies from the average were at least 4 °C, felt over Slovenia, most of Croatia and Turkey, but elsewhere air temperatures were up to 6 °C above the long-term average. Overall, the August-September period was on average noticeably warmer than normal across the region, mean air temperature ranged about the normal only across central and southern Greece. Mostly on the account of warm end of August and much of September, 60-day mean air temperature stood up to 2 °C above the long-term average across Serbia, North Macedonia, Aegean Turkey and in countries along the Adriatic Sea, while across northeastern half of the region including Hungary, Moldova, Romania, Bulgaria and most of central-western Turkey, mean air temperature of the August-September period was up to 3 °C warmer than usual.

ACCUMULATED WATER BALANCE
ANOMALY (mm)
30 JULY – 27 SEPTEMBER 2023



©4BS: COLA/IES

ACCUMULATED WATER BALANCE
PERCENTILE CLASSES
30 JULY – 27 SEPTEMBER 2023



©4BS: COLA/IES

In terms of surface water balance, dry to very dry conditions prevailed across much of the region this September. It was wetter than normal only over localised areas including central Hungary, northern Serbia, southwestern Bulgaria, southwestern Turkey and most noticeably across central Greece where one of the highest surface water levels were recorded this September. The 60-day accumulations covering the August-September period showed diverse surface water balance conditions across the region. Along the Adriatic Sea coastline and in central Serbia, August brought noticeable surplus but September saw dry to very dry conditions, in North Macedonia with the opposite change, leaving this part of the region in average 60-day surface water balance or with a deficit of up to 60 mm, locally in southern Croatia with a surplus of up to 90 mm. Across central Hungary, northern Serbia and central Greece, both months brought wetter than normal surface water balance conditions, altogether resulting in a 60-day surplus of up to 150 mm, over Greece well out of range. On the other hand, entire Moldova, most of Romania, eastern half of North Macedonia, eastern Greece, central Turkey and continental parts of Croatia and Bosnia and Herzegovina experienced deficit of surface water balance during both months, resulting in accumulated 60-day deficit between 60 and 120 mm.

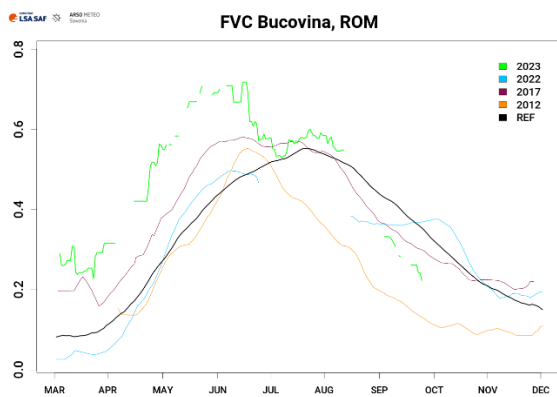
REMOTE SENSING - FRACTION OF VEGETATION COVER

Fraction of vegetation cover (FVC) is a vegetation index based on multi-channel remote sensing measurements (data from EUMETSAT's LSA SAF data base 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, it has also proved to be useful for drought monitoring. Values vary

according to the vegetation stage and to the damages of possible natural disasters (including drought). FVC values are in general low at the beginning of the growth season, the highest at full vegetation development, then FVC slowly drops with vegetation senescence. Line shape depends on the sort of vegetation at the given location.

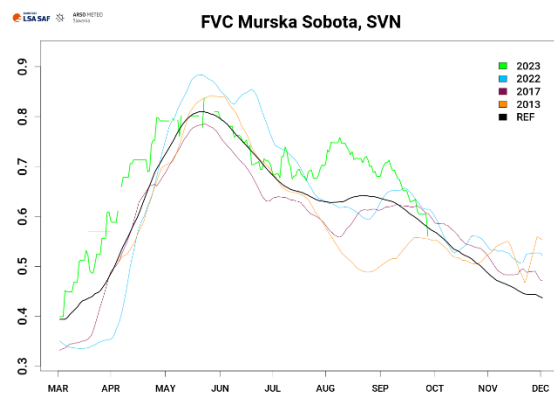
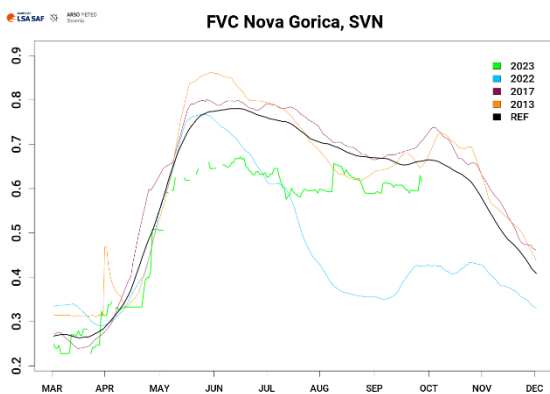
Graphs below present the **vegetation situation** as recorded on **29 September 2023** at selected locations across southeastern Europe. FVC values for year 2023 are presented as a green line. Graphs also include reference line (2004–2022) in black, and lines in light blue (year 2022), magenta (year 2017) and orange (year 2012, or 2013 for Slovenia) for comparison. Missing values or their sharp decline can be linked to prolonged cloudy weather, extreme weather events, snow blanket or changes to product by the product provider.

ROMANIA



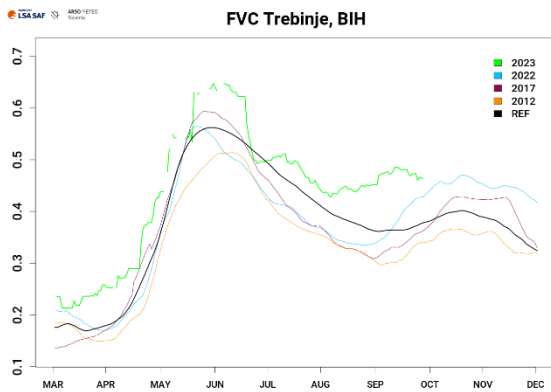
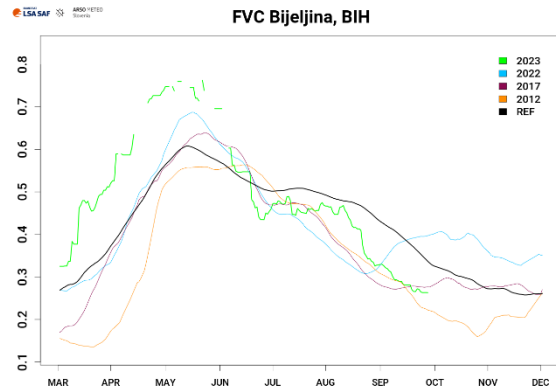
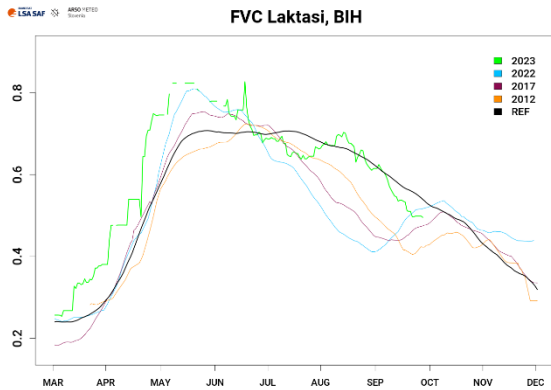
After an early and abundant vegetation growth and development during spring months, which resulted in almost 2 months earlier and well exceeded seasonal peak, fraction of cover with green vegetation was gradually brought down from 70 % to 50 % in second half of June, nevertheless levelling to the long-term average. July weather conditions provided temporal relief and recovery, before August and September proved unfavourable for regular vegetation development, speeding up the senescence and keeping FVC values 10 % below the average throughout September.

SLOVENIA



While vegetation in Nova Gorica, western Slovenia more or less followed its regular development during March and April, it did not develop to its average extent. It stopped its further development in early May, approximately 20 % below its usual peak extent, and remained varying about that level for the remainder of the season, with temporal and small-magnitude boosts and declines throughout these months. At the end of September, FVC remained at about the same level as in early May. Vegetation in Murska Sobota, northeastern Slovenia began its growing season a month earlier than normal and progressed well until its peak time in mid-May when weather conditions halted further growth at the average level. According to FVC, vegetation went through a regular development throughout the remainder of the season, with an unusual late summer boost of growth experienced in August.

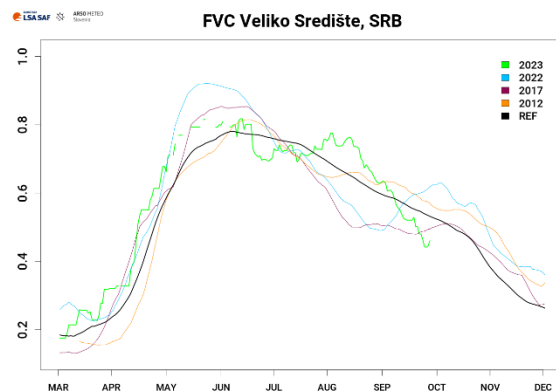
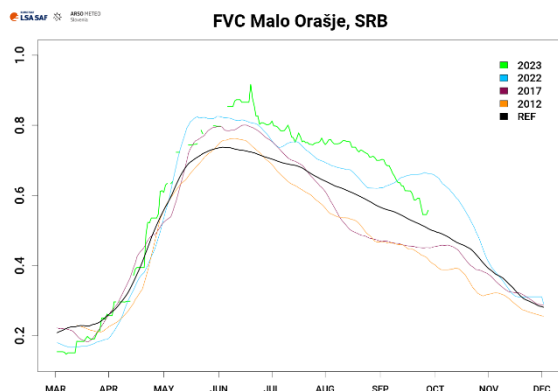
BOSNIA AND HERZEGOVINA (REPUBLIC OF SRPSKA)



According to FVC, vegetation growth began a couple of weeks earlier than normal at all three locations in Bosnia and Herzegovina. In Laktasi and Bijeljina along the northern plain it progressed at the regular rate, resulting in exceeding the seasonal peak in mid-May for about 10 % and 25 % respectively. Fraction of cover with green vegetation was in Trebinje in the south less abundant this spring, although peak part of the season saw some temporal boost in growth, exceeding the peak for 10 %.

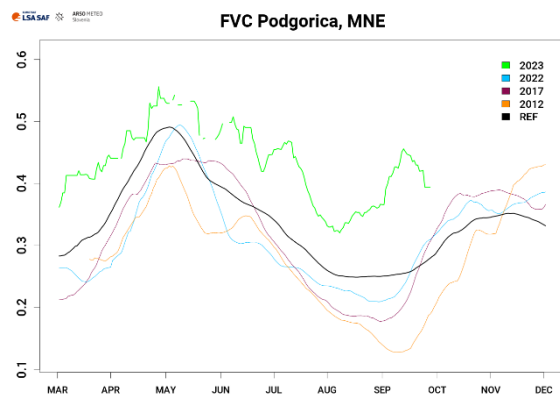
Sharp fall in fraction of vegetation cover down to the average can be observed for Trebinje in mid-June, followed by a temporal recovery and a regular rate of senescence throughout July. August and September weather conditions proved favourable for a much earlier onset of the second seasonal growth in Trebinje, which normally takes place in October. Vegetation in Laktasi and Bijeljina also experienced unfavourable weather conditions throughout June and July, which saw the level of vegetation cover over a unit of area reduce for 20 % in Laktasi and for 35 % in Bijeljina during that period. Vegetation in Bijeljina remained under-average for the rest of the season and had a similar second half of the season as in 2017. August supported a temporal boost in vegetation growth in Laktasi, which helped keep up with the regular level of cover and development.

SERBIA



In Malo Orasje, the growing stage of the vegetation season progressed as usual up to the time of seasonal peak in early June, after which the growth continued for another month, exceeding the regular peak cover by up to 20 %. Also the senescence phase that followed progressed at its usual rate, which on the base of exceeded seasonal peak and favourable weather conditions resulted in continuously 10–15 % higher than normal FVC throughout summer. Senescence was sped up in September, bringing the level of cover with vegetation down almost to the average for this time of year. In Veliko Srediste, vegetation season began slightly earlier than normal and progressed at its usual rate, resulting in reaching the seasonal peak cover in early May already. FVC remained at that level for over a month until temporally unfavourable weather conditions in mid-June brought the level of vegetation cover below the average. Mid-summer proved favourable for vegetation recovery and even unusual growth before senescence was sped up from mid-August onward and saw FVC values drop from up to 20 % above the average to below the normal by the end of September.

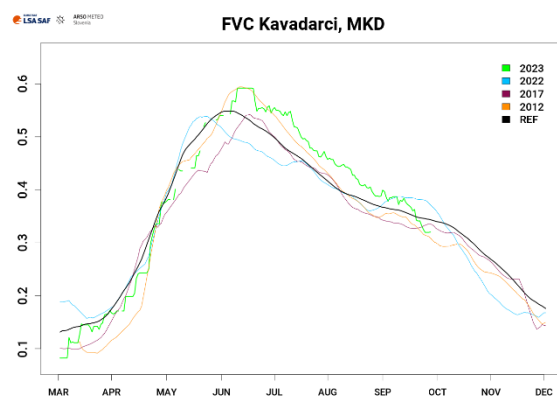
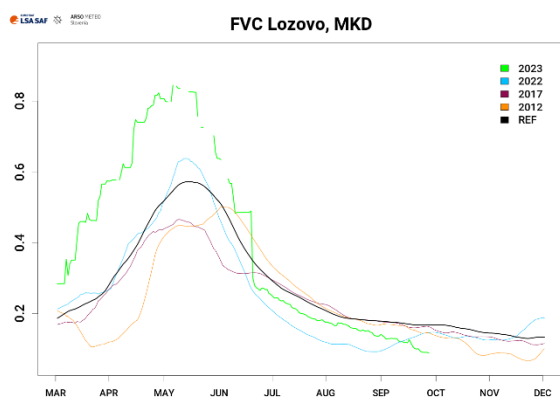
MONTENEGRO



According to the FVC, it was an abundant vegetation season this year in Podgorica, southern Montenegro as weather conditions at nearly all times allowed above-average level of cover with green vegetation. A good start to the season in March was followed by slightly exceeding the seasonal peak in early May, and even the senescence that followed progressed at the slightly lower rate than normal. On the average it kept level of vegetation cover up to 10 % above the average until the end of July.

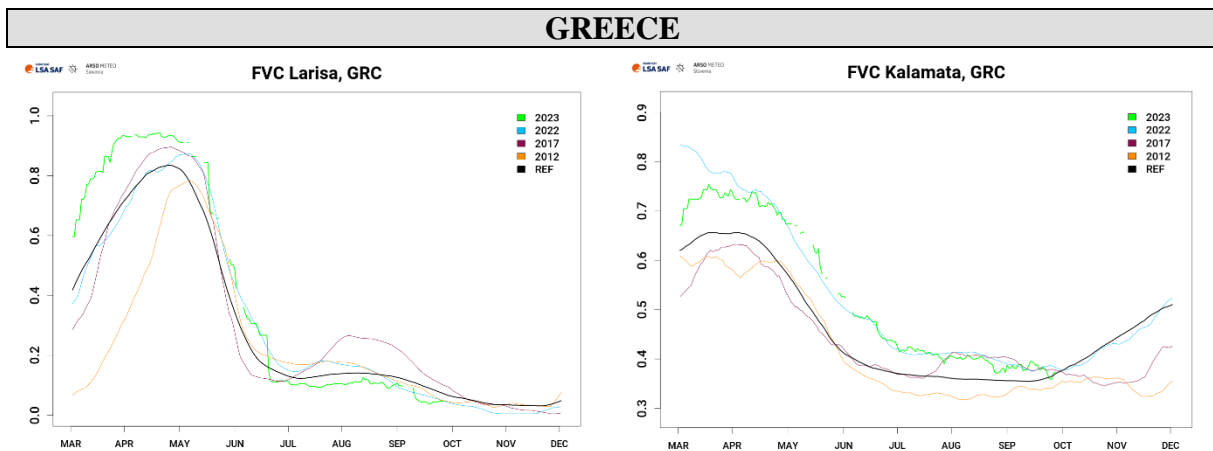
August and September brought weather conditions that encouraged a much earlier onset of the second seasonal peak, which normal begins in early October, altogether exceeding the average vegetation of the late summer to early autumn time of the year for 10–20 %.

NORTH MACEDONIA



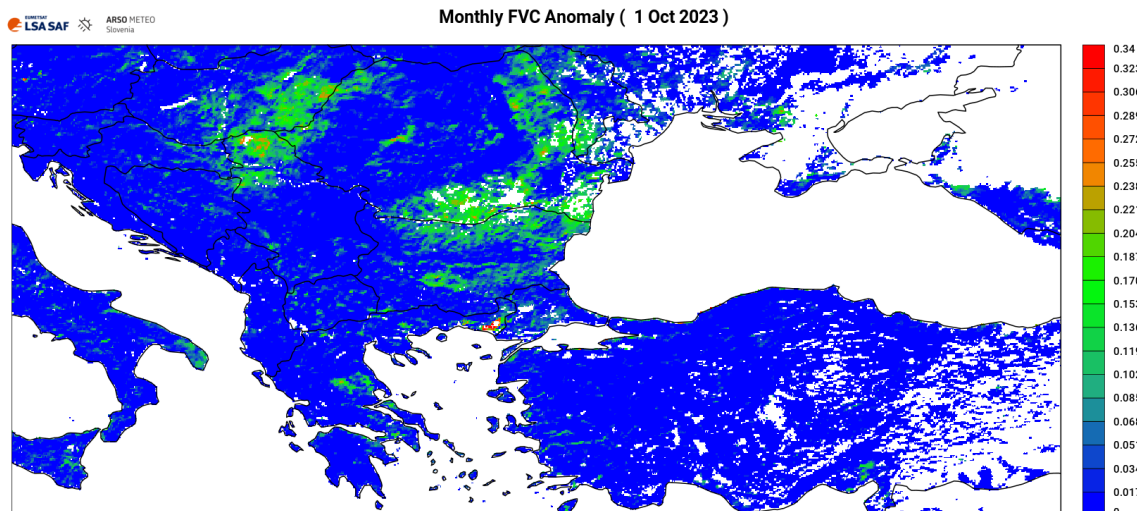
Vegetation in Lozovo, central North Macedonia experienced favourable weather conditions in the growing part of the season. Spring growth began early in March already and progressed at the slightly higher rate than normal, resulting in continuous run of abundant level of cover with green vegetation throughout the spring. Growth continued up to a regular

peak time in mid-May and reached a level of cover exceeding the average for 30 %. Second part of the season proved unfavourable for a regular senescence phase, especially in late spring which resulted in a rapid decline of FVC, from 85 % to 30 % between mid-May and mid-June. Weather conditions in months that followed supported a regular progression of the senescence phase, which saw FVC decline at the usual rate, although at slightly lower values than normal. In Kavadarci in souther part of the country, vegetation more or less followed the reference growth in spring, with a slight setback experienced from mid-May to mid-June. Afterwards, the growth resumed for a short period of time and the fraction of cover with green vegetation remained at the regular peak level for a month longer than normal, up to mid-July, postponing the onset of senescence which thus began later than normal but then progressed at its regular rate till mid-September.



According to FVC, vegetation in Larisa, central Greece experienced favourable conditions for growth and development throughout spring as the level of cover with green vegetation continued to exceed the long-term average by approximately 20 % in March and reached its peak cover well ahead of its time. The unit of area was at that stage nearly entirely covered with green vegetation, which is about 10 % higher than the average peak coverage, with weather conditions sustaining such fraction of cover for altogether more than a month. Senescence therefore began slightly later than normal and progressed at the regular rate, although unfavourable weather conditions in mid-June rapidly reduced the fraction of cover, which afterwards remained below-average but still followed its regular pattern of senescence for the rest of the season. Vegetation in Kalamata, southern Greece also experienced favourable weather conditions for growth and development this year. Up to 15 % greater fraction of cover with green vegetation was a constant this season, from March to September, very similar to a year before. At the end of September, vegetation cover appeared stagnant, with no clear sign of beginning its new cycle again, as it normally does at this time of year.

Figure below shows negative anomaly of **accumulated 30-day FVC values** as recorded on **1 October 2023** in comparison to the past 19 years (2004–2022), and is used experimentally.



The fraction of cover with healthy vegetation was at the beginning of October noticeably lower than normal for this time of year across vast areas in the region: in much of the plains engulfed by the Black Sea, The Dinaric Alps, The Carpathians and Moldova in the north, vegetation covered up to 20 % smaller unit of area than usual, similarly also over the Pannonian plain across northern Serbia and southeastern Hungary, where the fraction of cover was at certain locations even up to 30 % lower. Under-average was the fraction of cover in parts of central Greece, along southern Bulgaria, central Romania and locally across the Dinaric Alps where green vegetation covered 10-20 % lesser fraction of unit than usual at this time of year.

DROUGHT IMPACT REPORTS

ROMANIA

According to the European Commission estimates, Romania has experienced the weakest year of 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 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 will further affect oil industry ^[1].

[1] <https://stirileprotv.ro/stiri/actualitate/culturile-de-floarea-soarelui-distruse-de-seceta-cea-mai-slaba-productie-din-ultimii-cinci-ani.html>

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 ears.

Extracted from:

https://meteo.hr/klima.php?section=klima_pracenje¶m=spi&el=prspi

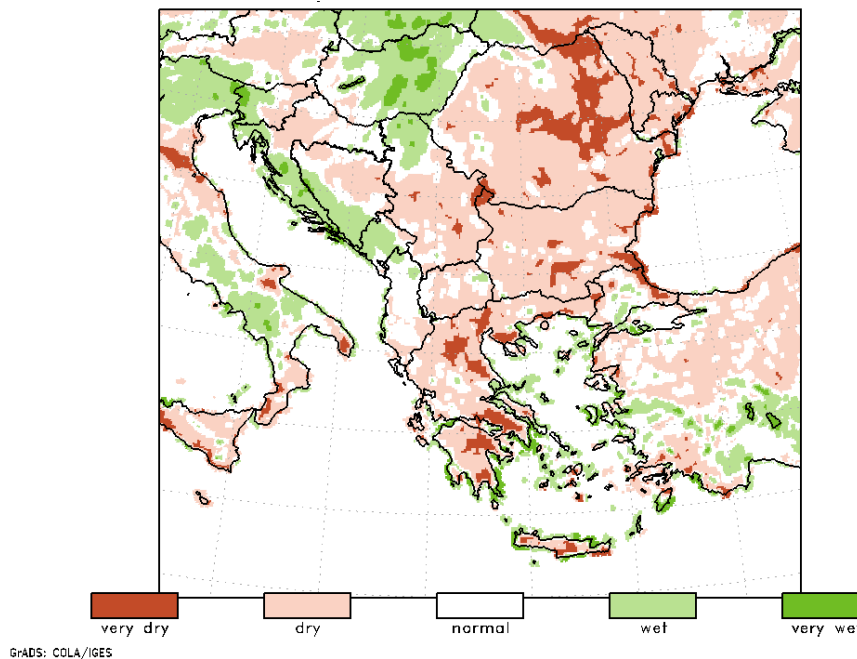
https://meteo.hr/klima.php?section=klima_pracenje¶m=ocjena

https://meteo.hr/proizvodi.php?section=publikacije¶m=publikacije_publicacije_dhmz&el=bilteni (preliminary report; publication is in preparation)

https://meteo.hr/klima.php?section=klima_pracenje¶m=spi&el=karte_suse&Week=231012

OUTLOOK

Figure below shows model simulations of the **60-day accumulated surface water balance** in historical percentile classes for the time period **between 8 September and 6 November 2023**.



Evident lack of rain and warmer than normal air temperatures in first months of autumn will leave much of the region experiencing drier than normal surface water balance conditions. In comparison to the August-September accumulations, the then-existing surface water balance anomalies will greatly intensify, meaning most of the central and eastern part of the region is expected to experience even drier surface water balance conditions, with some parts of it expected to experience very dry conditions, while the belt along the Adriatic Sea and over the Pannonian Basin, surface water balance conditions are expected to become even wetter than before, locally even very wet. Over the wider Aegean Sea area, dry to very dry conditions are expected to replace the previously wet to very wet conditions.

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-hydrostatic 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 have a 5-percent range, and each of the middle three classes has 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.