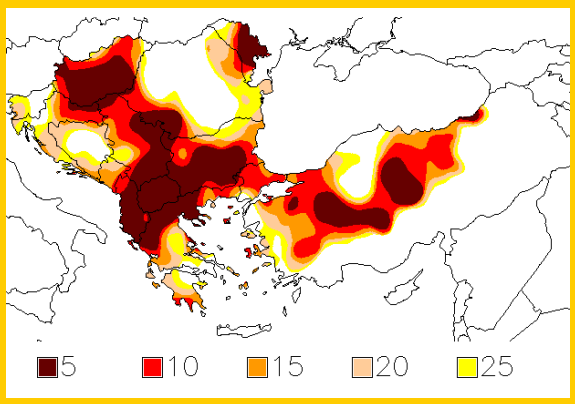
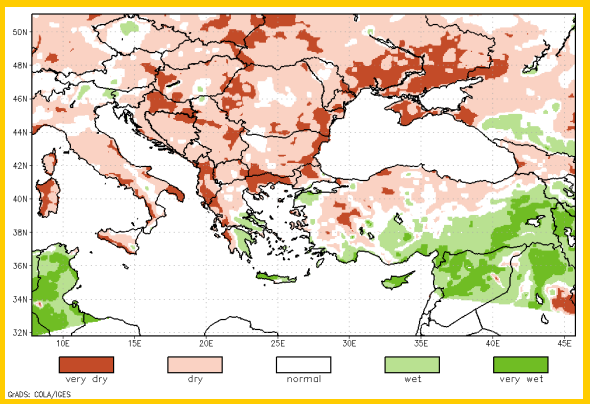
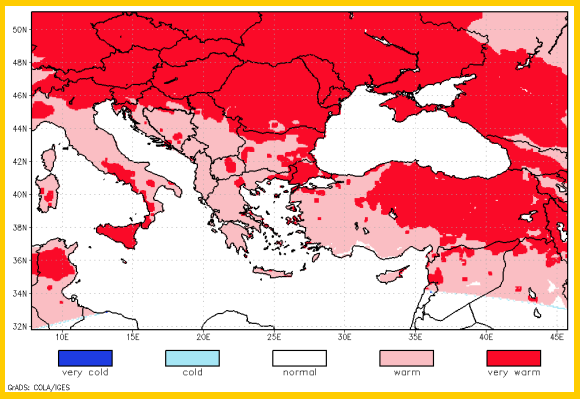
DROUGHT MONITORING BULLETIN

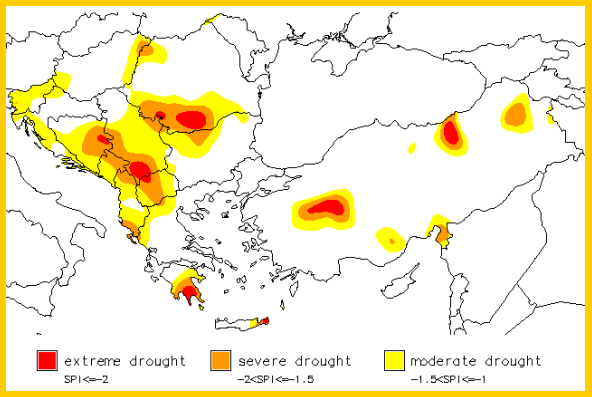
Overview from February to November 2019

HOT SPOT









Precipitation percentiles for March *(top left),* ***surface water balance between 31 January–31 March*** *in percentile classes (top right),* ***mean air temperature for June*** *in percentile classes (bottom left),* ***3-month SPI for October*** *(bottom right).*

Year 2019 was characterised mostly by alternating periods of dry and wet conditions, differently so across the region. February and March were very dry across all of the region with vast part of the territory under prominent lack of rain (top left figure), which left topsoil level in evident lack of moisture over the entire region, with the exception of Aegean area and southern Turkey (top right figure). While May brought unusually high amount of precipitations to northwestern half of Balkan Peninsula, Greece and most of Turkey experienced another dry period. With June came unusually high air temperature for that time of year and consequently high evapotranspiration, especially over northeastern half of Balkan Peninsula and central-eastern Turkey where mean air temperatures classified among the highest 5 % of local historic data (bottom left figure). June and July were wetter than usual over southern half of Balkan Peninsula and central-western Turkey. With August though, dry conditions began to spread across the region that over Balkan Peninsula came to an end only with a very wet November, although over Turkey dry period lasted throughout autumn months (bottom right figure).

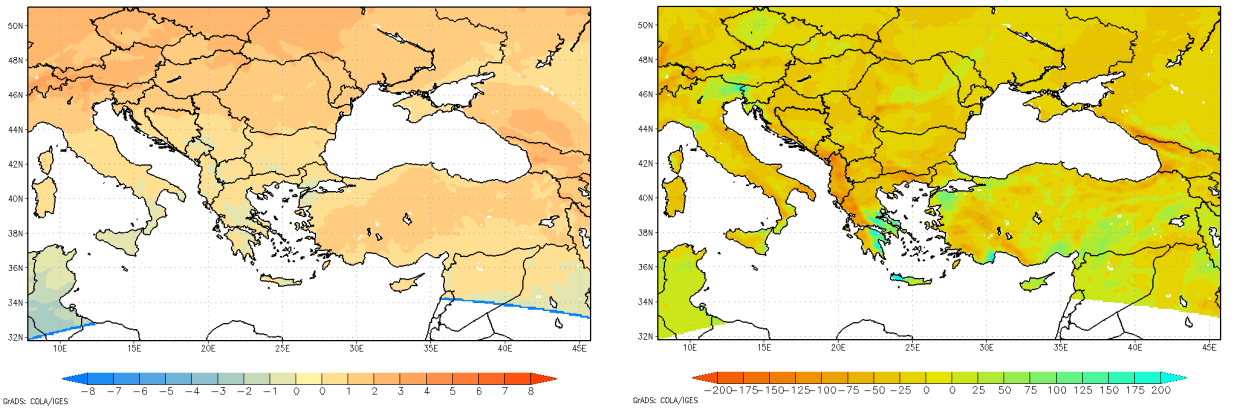
AIR TEMPERATURES AND SURFACE WATER BALANCE

*Figures in this section present anomalies from the average of 1986-2015 period of monthly **air temperature** and accumulated **surface water balance** from **February to November 2019**.*

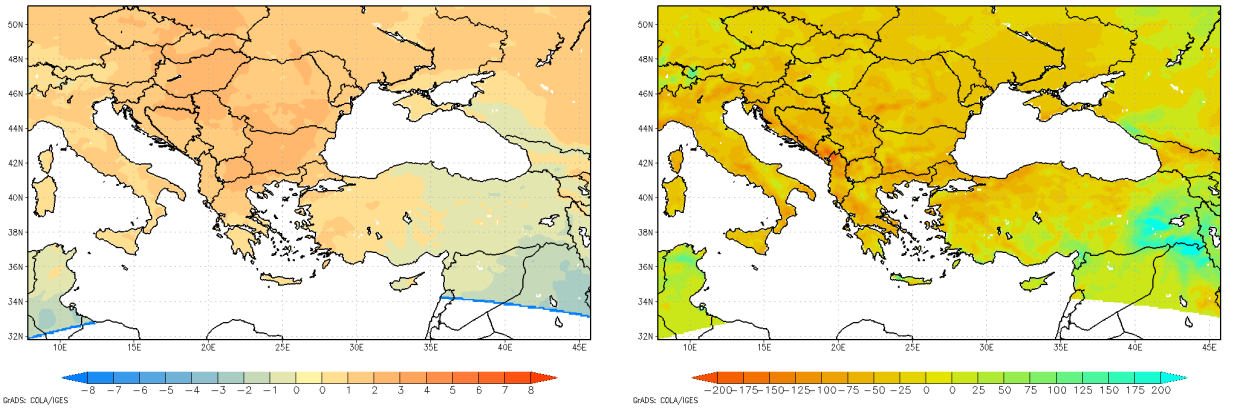
AVERAGE AIR TEMPERATURE ANOMALY [°C]

SURFACE WATER BALANCE ANOMALY [mm]

FEBRUARY 2019



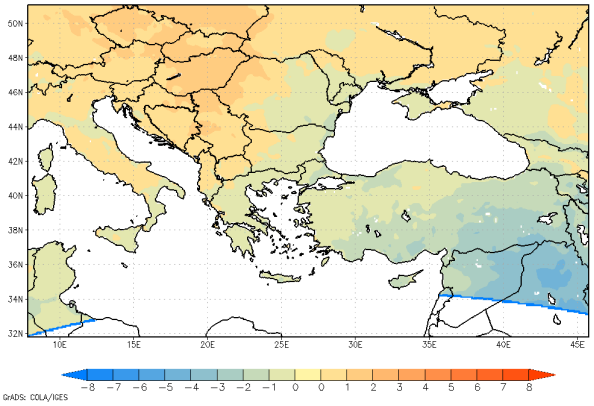
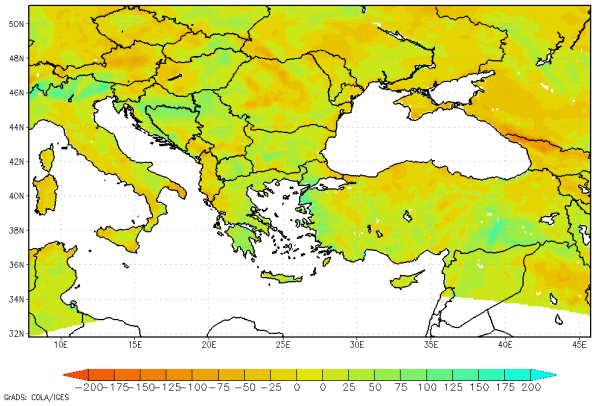
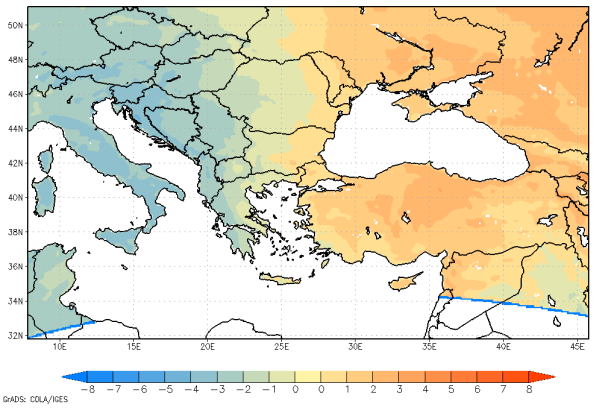
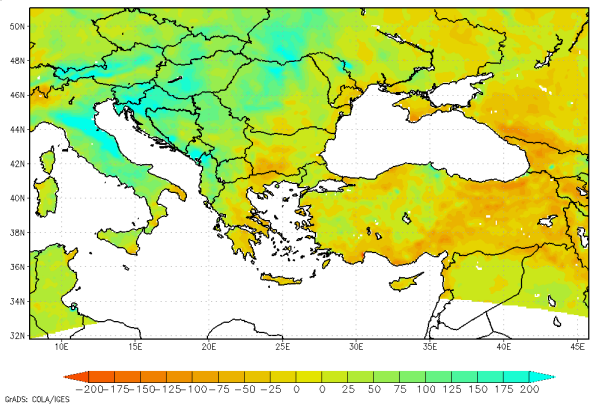
MARCH 2019



February was a warm month across the northern belt of the region from Slovenia to Romania and over Turkey as monthly mean temperature was up to 2 °C above the average. Elsewhere, it was mainly month of average or slightly-below average air temperatures. Precipitation-wise, it was also a very dry month, especially over continental Greece, Albania, North Macedonia, Bulgaria and areas along the Black Sea where low rainfall rate classified among the lowest 5 % of past local records. Consequently, surface water balance level over these areas was way below the average, ranging from -75 mm to -150 mm, the lowest affecting mostly Albania and Mediterranean Greece. Parts of Hungary, Croatia, Romania and Turkey also experienced noticeable lack of rain, leaving surface water balance deficit range up to -50 mm. However, areas along the Aegean Sea experienced a very wet month as water balance surplus ranged between 75–125 mm.

Similarly cold but even wetter conditions were later, in **March**, present over eastern half of Turkey while over entire Balkan Peninsula and western Turkey, above-average air temperature continued and exceeded the usual values for even up to 3 °C in North Macedonia, Bulgaria, Hungary and in local areas in between. In addition, also lack of rain persisted into March with rainfall rate of below 10th percentile now experienced over entire Hungary, across central Balkan Peninsula to northern Greece and also over southern Moldova and wider central Turkey. March alone brought surface

water balance deficit of additional -125 mm to -175 mm to areas along south Adriatic Sea, Greece and Bulgaria, and between -50 mm and -100 mm elsewhere. Persisting lack of rain throughout February and March resulted left the entire region, with exception of Aegean Greece and southeastern Turkey, experience dry or very dry beginning of spring.

AVERAGE AIR TEMPERATURE ANOMALY [°C]	SURFACE WATER BALANCE ANOMALY [mm]
APRIL 2019	
	
MAY 2019	
	

As **April** came, vast part of Balkan Peninsula, Greece and western and central Turkey experienced a welcome relief through above-average amount of precipitations and more or less average air temperatures, meaning also evapotranspiration did not have much influence on further drying out the topsoil level. Over those areas, monthly accumulations of surface water balance improved mostly for up to 75 mm, locally all along the Croatian-Bosnian border and far western Turkey for up to 125 mm. On the other hand, above-average mean monthly air temperature of up to 2 °C continued over Hungary where also precipitation level was under-average, just like over central Romania and northern Turkey, leaving these parts in continued dry conditions. Monthly surface water balance brought accumulated deficit of additional -50 mm, in Turkey of up to -75 mm.

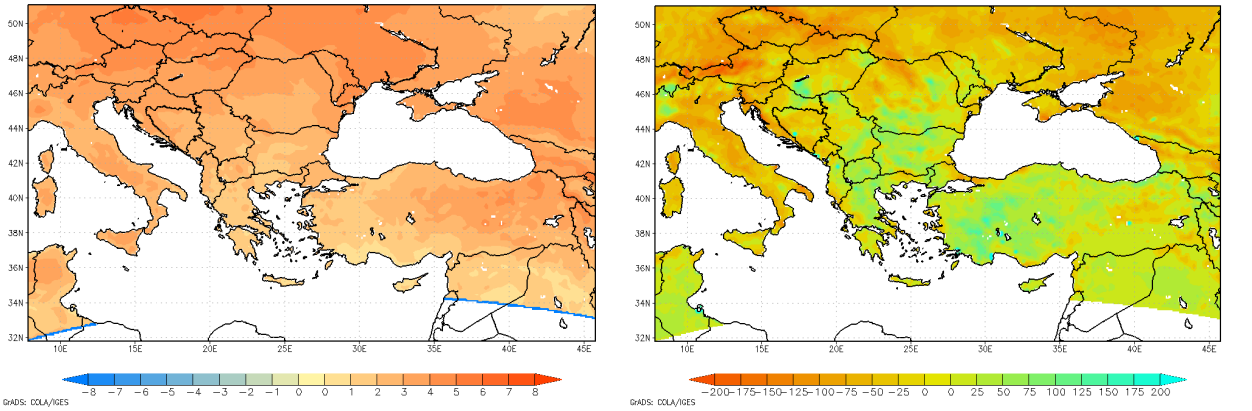
May brought noticeable change in surface water balance conditions over the region, in either extreme. On one hand, western half of Balkan Peninsula experienced a month of colder-than-usual air temperatures, with negative anomalies from the average of up to -2 °C along the central line to up to -4 °C over Slovenia and Croatia, while at the same time experiencing a very wet month. Monthly surface water balance surplus ranged between 50-125 mm in small areas over central and eastern Balkan Peninsula, but up to 175 mm and locally above 200 mm over Montenegro, along Croatia, Slovenia and along to northwestern quarter of Romania. At the same time, May was

unusually warm over Turkey with mean month air temperatures exceeding the average for up to 2 °C, in northern Turkey up to 3 °C, but also very dry especially in its central and southern parts along with Aegean Greece and southwestern Bulgaria. These parts of the region also received precipitation amount as low as to classify among the lowest 5 % of local historic records, resulting in a very dry May conditions, with surface water balance deficit of up to -75 mm in Greece and most of Turkey, in mountainous Turkey even up to -125 mm.

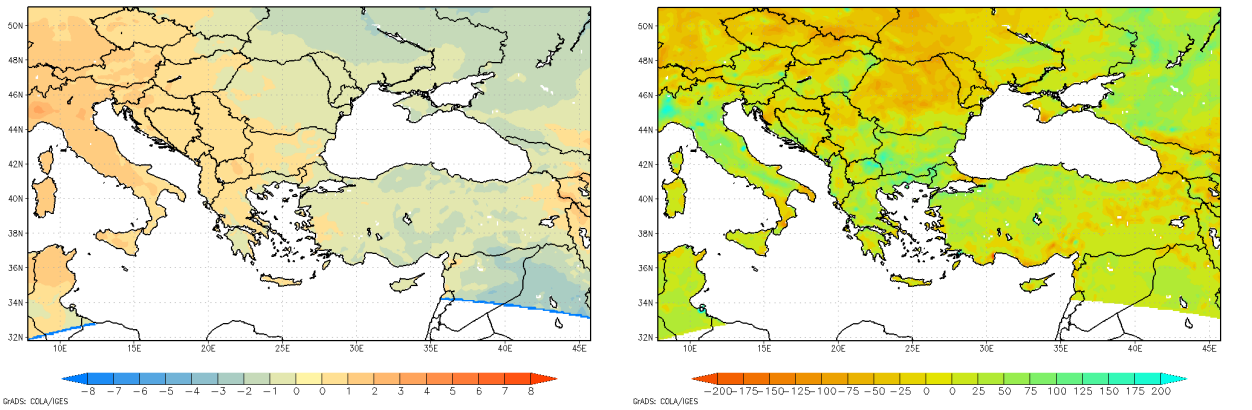
AVERAGE AIR TEMPERATURE ANOMALY [°C]

SURFACE WATER BALANCE ANOMALY [mm]

JUNE 2019



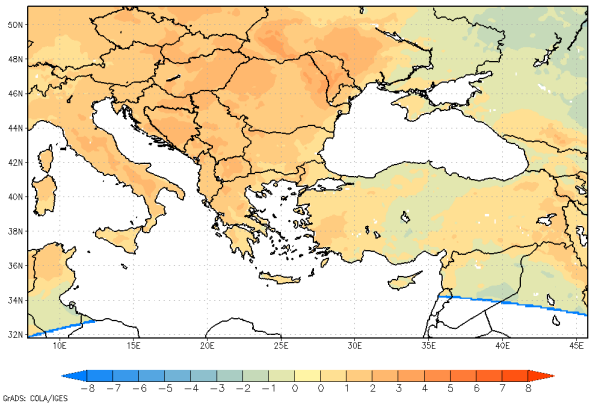
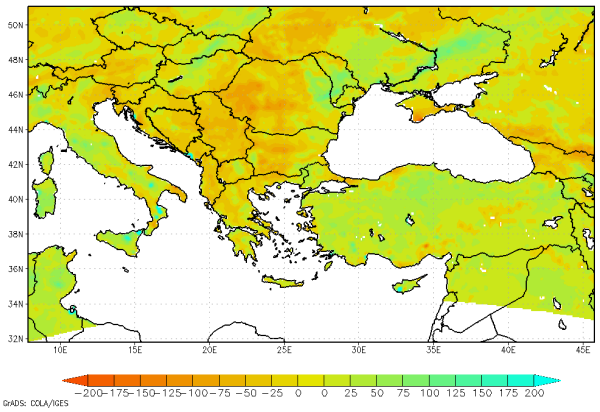
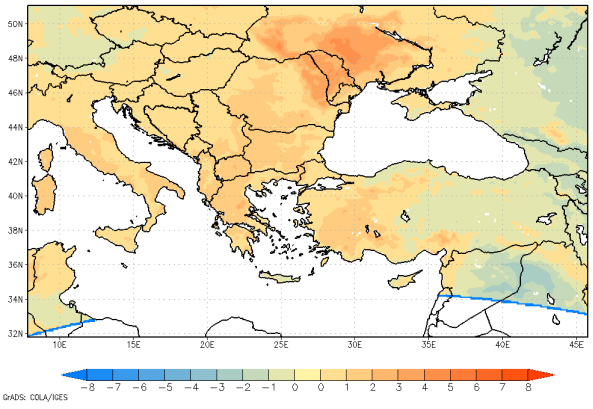
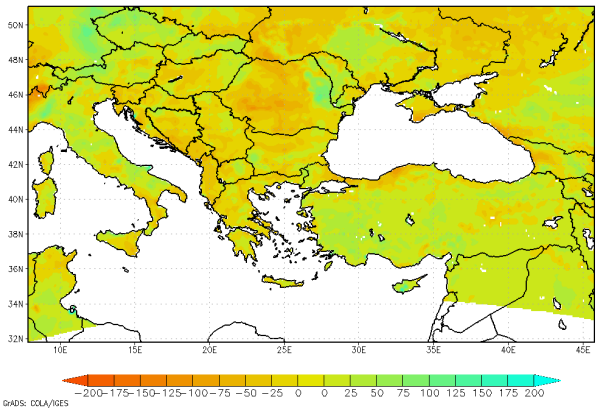
JULY 2019



In **June**, most of the region was faced with surface water balance conditions opposite to those experienced in in May. Unusually high air temperatures were present over the entire region, exceeded the monthly average for up to 4 °C over Croatia, Slovenia, Hungary, Romania, Moldova and northeastern half of Turkey, locally even up to 5 °C, which classified them among the highest 5th percentile of local historic records. Elsewhere, monthly air temperature anomalies ranged between 2-3 °C. In addition, Slovenia and Croatia experienced extreme lack of rain that classified among the lowest 5th percentile, resulting in surface water balance deficit range between -75 mm and -100 mm. Areas where precipitation level in June was less than sufficient includes also countries along the Adriatic Sea, Hungary, northwestern quarter of Romania and southeastern Turkey, leaving deficit in monthly surface water balance deficit of mainly up to -50 mm. On the other hand, higher-than-usual precipitation amount over eastern and southern Romania, southern half of Balkan Peninsula and western and central Turkey, joined with low evapotranspiration left that part of the region in high surplus of surface water balance, mostly between 75 and 175 mm, bringing dry spring conditions to an end.

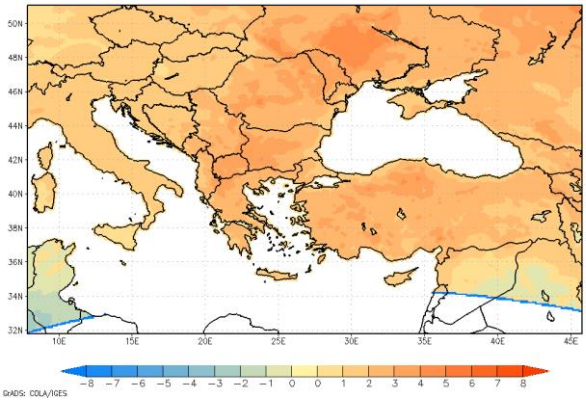
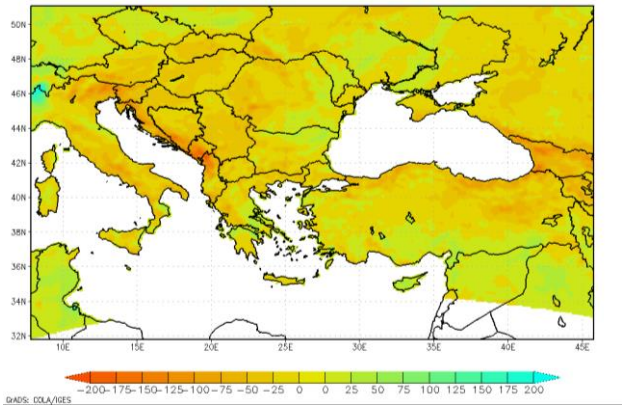
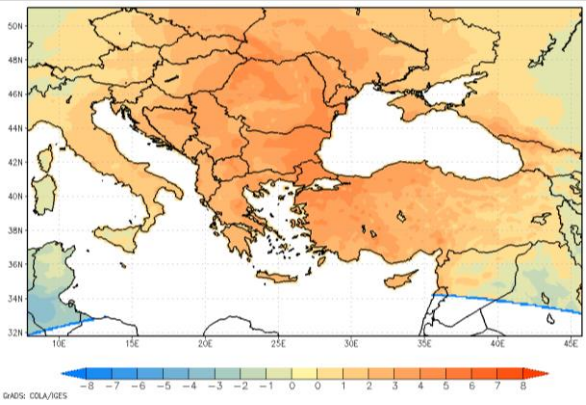
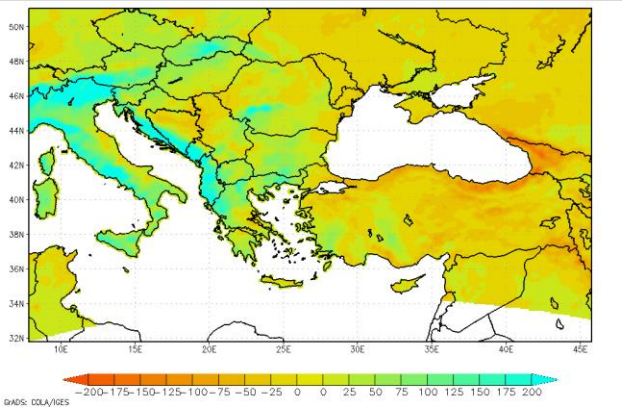
Temperature-wise, **July** was a relatively average month although locally across central third of

Turkey monthly mean air temperature was up to 2 °C below the average and locally over Slovenia and parts of Croatia they were up to 2 °C above the average. Despite the latter, higher precipitation amount brought welcome water balance surplus of up to 50 mm to local parts of northwestern Balkan Peninsula, although water balance deficit of additional up to -50 mm was present over some scattered areas which maintained dry conditions. Extreme lack of rain over Moldova and southeastern Turkey, also in parts of Romania, further supported dry conditions there and brought additional water balance deficit of up to -75 mm. Meanwhile across southern half of Balkan Peninsula and northwestern half of Turkey, wetter than usual conditions of June continued into July and increased surplus of water balance for up to 75 mm, locally in North Macedonia and northeastern Greece for up to 125 mm.

AVERAGE AIR TEMPERATURE ANOMALY [°C]	SURFACE WATER BALANCE ANOMALY [mm]
AUGUST 2019	
	
SEPTEMBER 2019	
	

Turkey experienced **August** of mostly average air temperatures and with higher precipitation amount than usual, the combination that maintained wet conditions across most of the country. Monthly surface water balance deficit over Turkey's south-east was minimal while it exceeded the average monthly values for up to 75 mm. On the other hand, conditions noticeably worsened all over Balkan Peninsula where air temperatures rose for up to 2-3 °C above the average, over Moldova even up to 4 °C, and vast part Greece, Albania, North Macedonia and southern Romania experienced a precipitation level among the lowest recorded. Also Montenegro, Croatia and Slovenia experienced noticeable lack of rain, altogether resulting in deficit of monthly water balance of up to -75 mm over majority of Balkan Peninsula, and up to -125 mm over western Romania. While air temperature anomalies in August were the highest in Moldova, so were the

wettest conditions where monthly water balance surplus reached as high as 125 mm.
Such unusually warm and at the same time unusually wet conditions over eastern Romania and Moldova persisted into **September** as mean monthly air temperature exceeded the average for even up to 4 °C, but with monthly surplus of water balance again stretched well above the average, between 50-100 mm. Monthly accumulations of water balance were mostly in positive-average values also across most of Turkey despite noticeable lack of rain across its north and south-east, among reasons for this also being colder than normally air temperatures for that time of year. However, September was for up to 2 °C warmer than usually over Balkan Peninsula and western Turkey and at the same time precipitation level for this time of year mostly lower than usual, especially in southern Romania. On monthly scale, deficit of surface water balance prevailed across Balkan Peninsula, mostly up to -50 mm but over Carpathian Romania also up to -100 mm.

AVERAGE AIR TEMPERATURE ANOMALY [°C]	SURFACE WATER BALANCE ANOMALY [mm]
OCTOBER 2019	
	
NOVEMBER 2019	
	

All across the region, **October** was unusually warm and mostly dry. With the exception of northwestern part of Balkan Peninsula where monthly mean air temperature exceeded the average for up to 2 °C , the rest of the region experienced anomalies of monthly mean air temperatures as high as 3-4 °C, classifying October among one of the hottest of past records. Along with greatly increased evapotranspiration, vast area all along central Turkey and all countries along the Adriatic Sea received negligible amount of precipitations, leaving these areas with monthly surface water balance deficit of up to -50 mm, even higher over the Alps, along southern Adriatic Sea and northern Greece where it ranged between -100 mm and -150 mm. Despite warmer air temperatures, the normal or slightly higher precipitation level from Moldova to Bulgaria, over Aegean Greece and southern Turkey kept that part of the region within more or less the expected

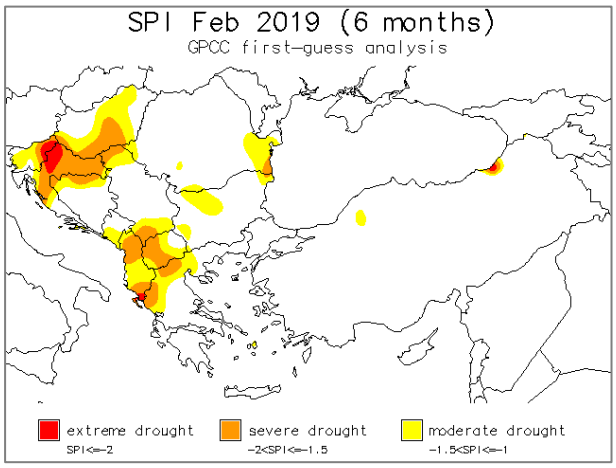
surface water balance level for October, between -25 mm and 25 mm, in small local areas up to 50 mm.

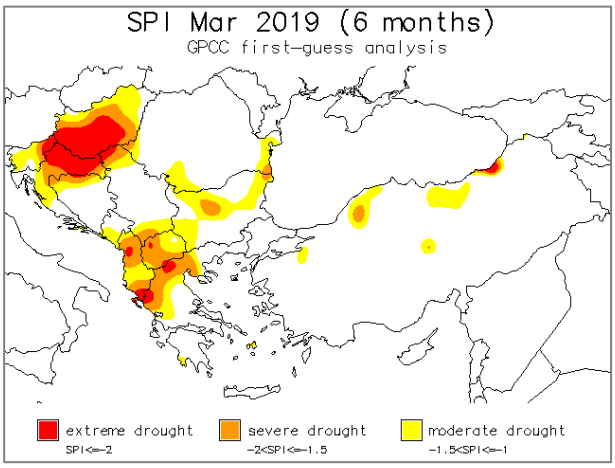
Unusually warm air temperatures for that time of year continued into **November** across the entire region. Anomalies in air temperatures even intensified in November, stretching 4-5 °C above the average over northeastern half of Balkan Peninsula and western Turkey and between 2-3 °C over western Hungary, Slovenia, all along the Adriatic Sea to Greece and over eastern Turkey. Also dry conditions Along with warmer air temperatures, Moldova and entire northern and eastern Turkey experienced noticeable lack of rain in November, leaving these countries with accumulated surface water balance deficit up to -50 mm, along Turkey's northern coastline even up to -125 mm and further supporting dry conditions. On the other hand, other countries of Balkan Peninsula experienced a wet month which brought dry conditions to an end. Highest amount of precipitations were present all along the Adriatic Sea area, resulting in over 200 mm of monthly water balance surplus, but also over northern Greece, North Macedonia and Bulgaria where monthly surplus in water balance ranged between 100-175 mm.

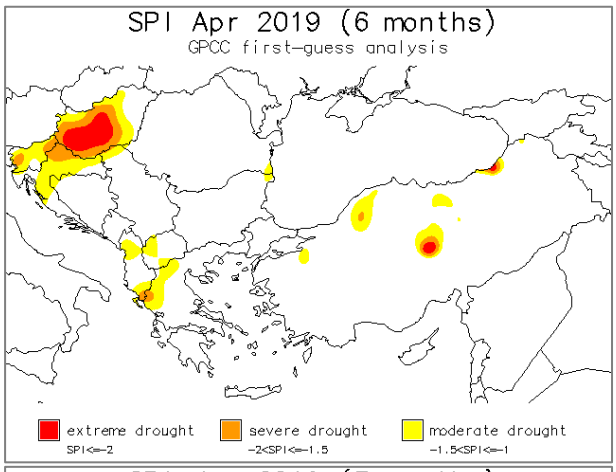
STANDARDIZED PRECIPITATION INDEX

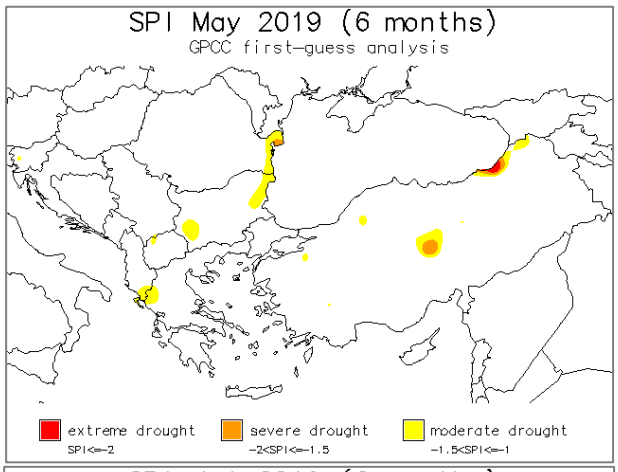
Drought situation with regard to precipitation accumulation is presented by Standardized Precipitation Index (SPI). The SPI calculation is based on distribution of precipitation over long–time period (30 years, in our case long–term average 1961–1990 was used). SPI can be calculated at various time scales 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 (average) SPI for any place and time period is zero. SPI values above zero indicate wetter periods while values below zero indicate drier periods. Only the dry part of the extreme anomalies is presented on the maps.

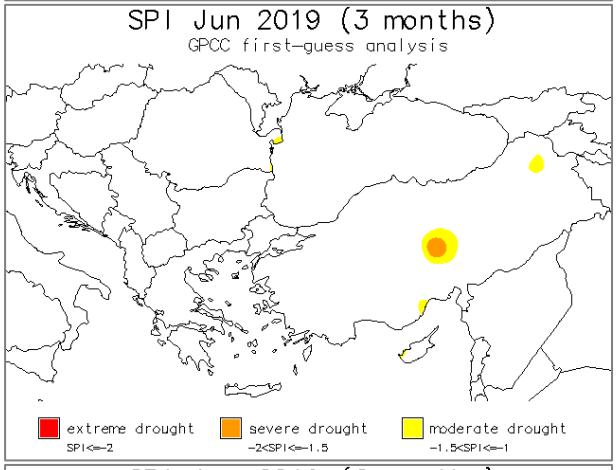
Maps of SPI for one and three months, which can be used for estimation of meteorological and agricultural drought respectively, have already been published in monthly bulletins during vegetation season 2018. Maps below present SPI for 6 months which tells us more about hydrological conditions throughout the year.

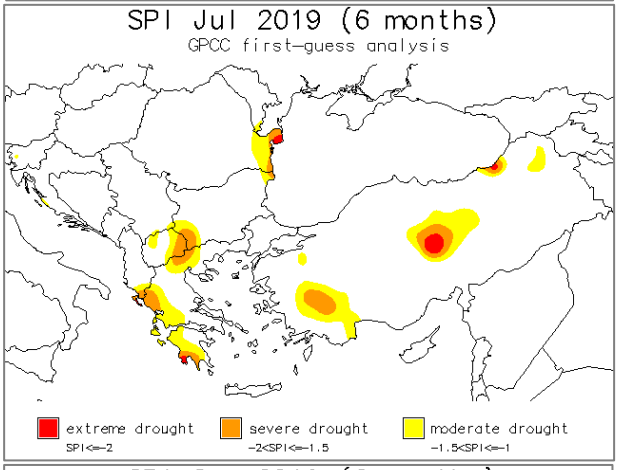


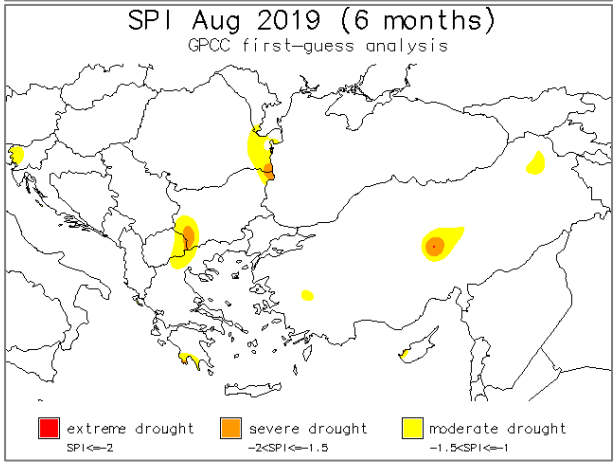


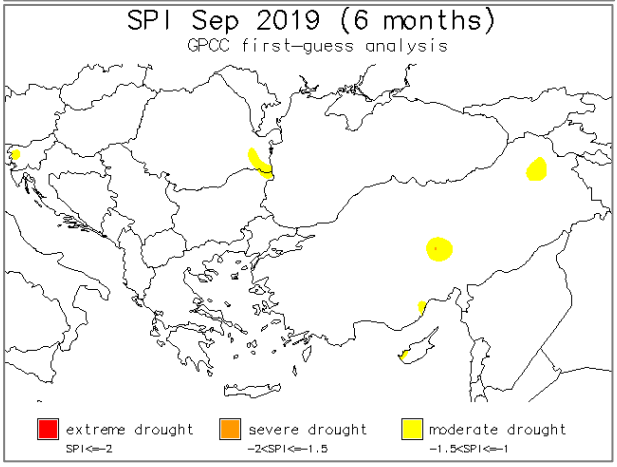

SPI Apr 2019 (6 months)
GPCC first-guess analysis
extreme drought
SPI<=-2
severe drought
-2<SPI<=-1.5
moderate drought
-1.5<SPI<=-1

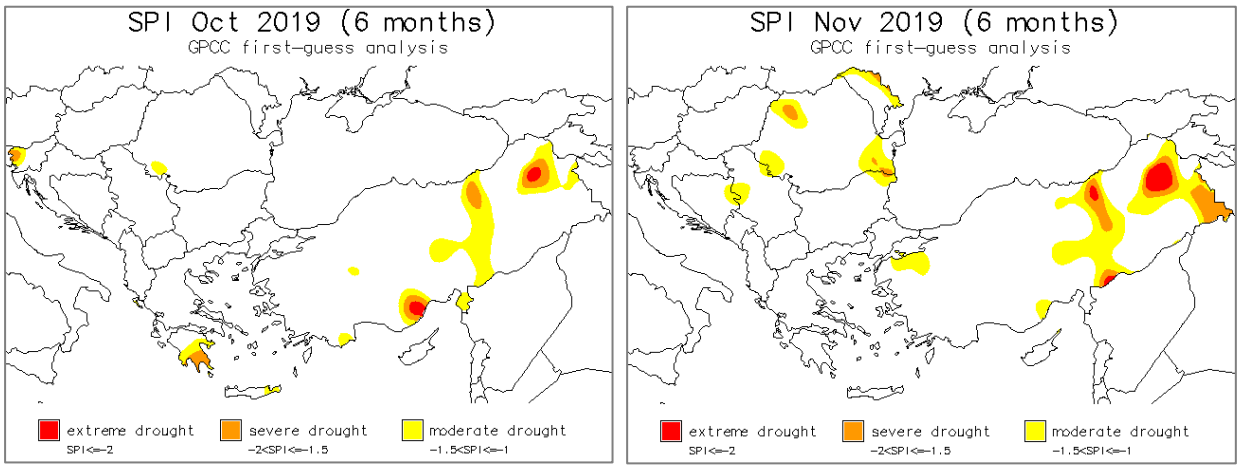

SPI May 2019 (6 months)
GPCC first-guess analysis
extreme drought
SPI<=-2
severe drought
-2<SPI<=-1.5
moderate drought
-1.5<SPI<=-1


SPI Jun 2019 (3 months)
GPCC first-guess analysis
extreme drought
SPI<=-2
severe drought
-2<SPI<=-1.5
moderate drought
-1.5<SPI<=-1


SPI Jul 2019 (6 months)
GPCC first-guess analysis
extreme drought
SPI<=-2
severe drought
-2<SPI<=-1.5
moderate drought
-1.5<SPI<=-1


SPI Aug 2019 (6 months)
GPCC first-guess analysis
extreme drought
SPI<=-2
severe drought
-2<SPI<=-1.5
moderate drought
-1.5<SPI<=-1


SPI Sep 2019 (6 months)
GPCC first-guess analysis
extreme drought
SPI<=-2
severe drought
-2<SPI<=-1.5
moderate drought
-1.5<SPI<=-1

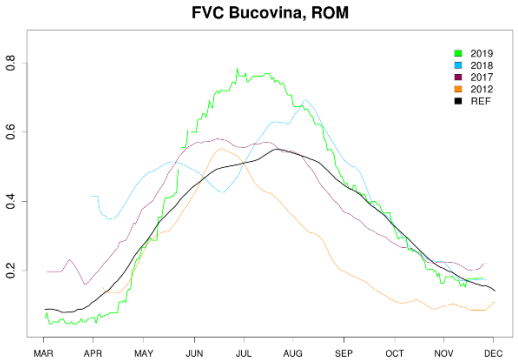


With October, December 2018 but especially February and March 2019 all bringing noticeable lack of rain across many parts of the region, it is evident (also from SPI6 for February and March) that winter half of the year presents a severely dry period in hydrological sense, especially in countries of southern and northeastern Balkan Peninsula but also over its north-west where winter half of the year can be considered extremely dry. As drought conditions mostly decreased over Balkan Peninsula by May and June, figures of SPI6 from April through July show gradual worsening of the situation over limited areas in Turkey's central, western and northeastern parts. SPI6 for July indicate a moderately to severely dry first half of the year also over western and northern Greece. As dry conditions over scattered areas across the region mainly decreased to moderate conditions by September or even came to an end, eastern part of Turkey started to experience gradual worsening again to from October on, mostly due to severely to extremely dry May, October and November months. SPI6 for October and November therefore indicate summer half of the year was moderately to severely dry in hydrological sense over eastern half of Turkey.

REMOTE SENSING – FRACTION OF VEGETATION COVER

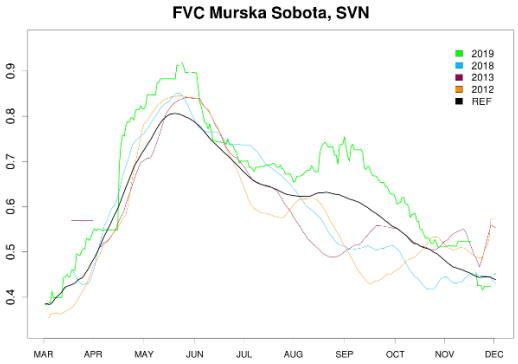
Fraction of vegetation cover (FVC) is vegetation index, based on multi–channel remote sensing measurements (data from Eumetsat's LSA SAF database is used for products in this bulletin). FVC shows fraction of the total pixel area that is covered by green vegetation, which is relevant for applications in agriculture, forestry, environmental management and land use, it has also proved to be useful for drought monitoring. 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 and then FVC slowly drops with vegetation senescence. Line shape depends on sort of the vegetation.

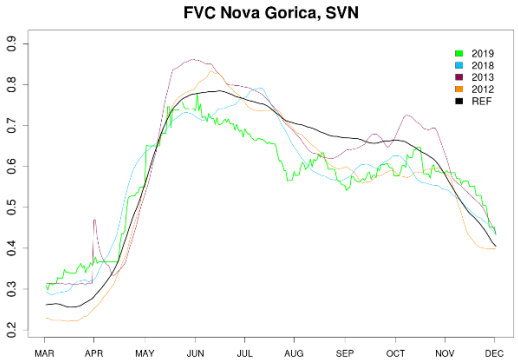
Graphs below present **vegetation development** from **March to December 2019** at 13 locations across Southeastern Europe, as indicated by FVC index. FVC values for year 2019 are presented as green line. Graphs also include reference line (2004–2018) in black, and lines in light blue (year 2018), magenta (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 or snow blanket.

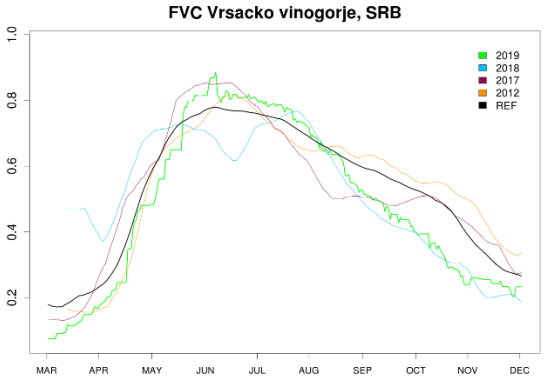


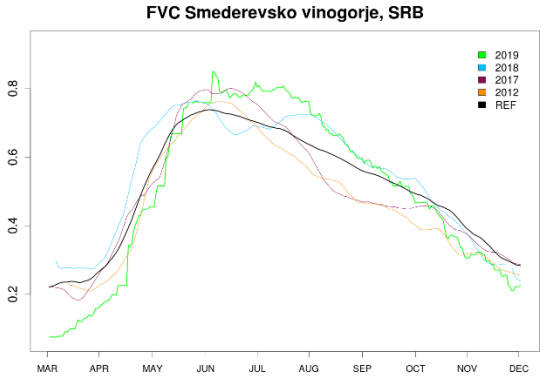
Graphs of FVC at the following locations (from top left to bottom right):

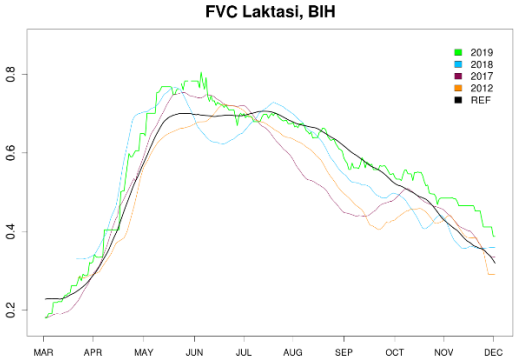
Romania – Bucovina;
Slovenia – Murska Sobota, Nova Gorica;
Serbia – Veliko središte (Vršacko vinogorje), Malo Orašje (Smederevsko vinogorje);
Bosnia and Herzegovina – Laktaši, Bijeljina, Trebinje;
Montenegro – Podgorica;
North Macedonia – Lozovo, Kavadarci;
Greece – Larisa, Kalamata.

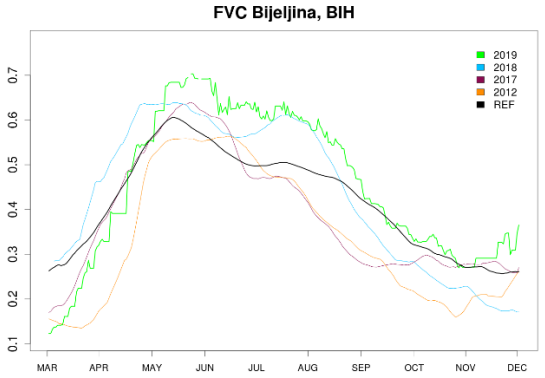


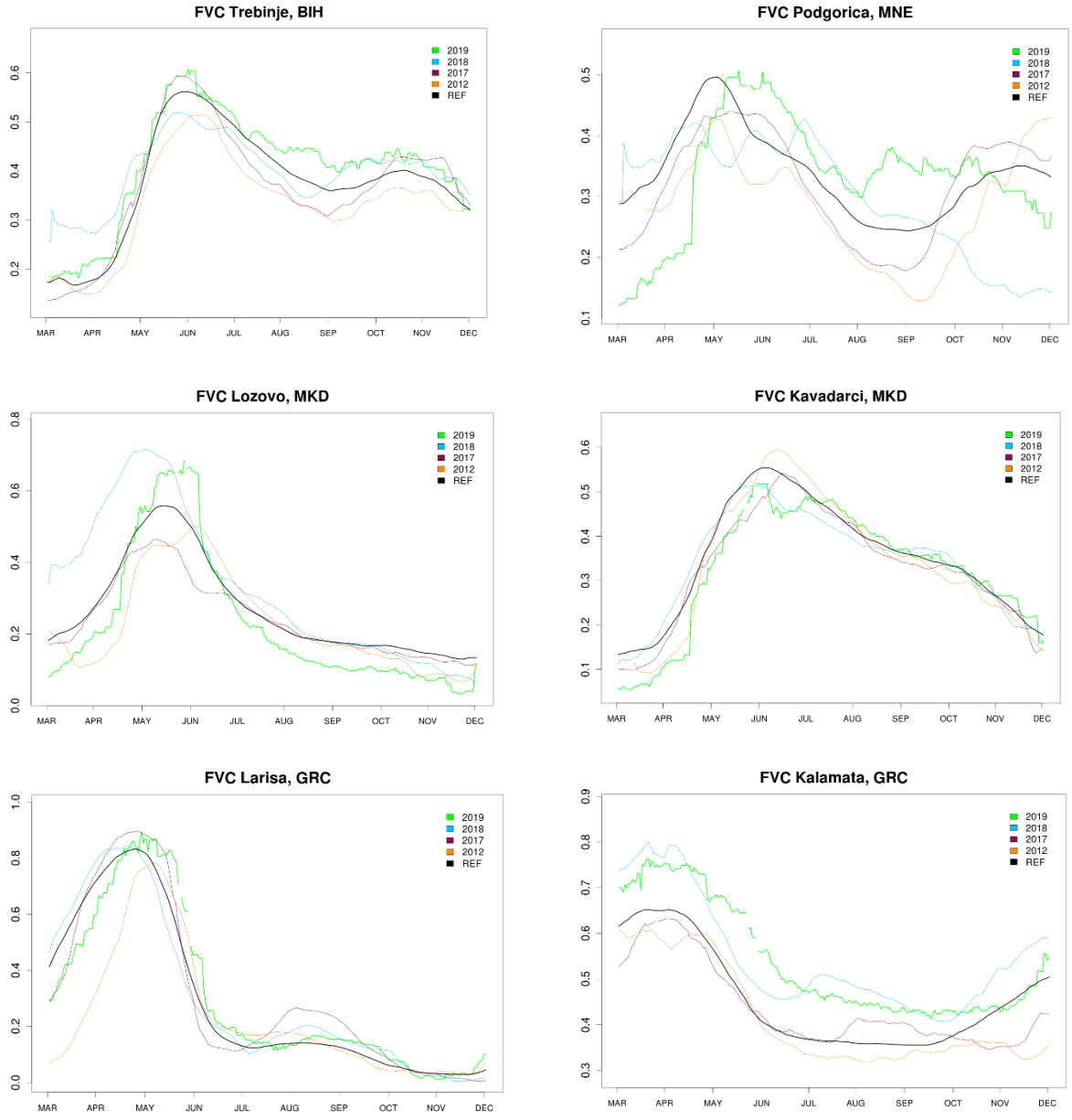












IMPACT REPORTS

MOLDOVA

From mid-July to mid-August, the State Hydrometeorological Service issued several drought warnings, appealing to economy and the population to rationally consume water resources. Authorities have also set up tents in the capital where people suffering from heat could cool down or receive medical help, in extreme cases. General Inspectorate for Emergency Situations has also asked the citizens to comply with the fire prevention rules [1, 2].

ROMANIA

According to National Meteorological Administration, many areas of Romania suffered of extreme drought over the summer months. There were places where soil was dry up to a meter into the ground. Negligible amount of precipitation over summer months has left maize production at only 50 % of that achieved a year before [3].

BULGARIA

Bulgaria was in 2019 faced mostly with hydrological drought. The level of water in the largest dam in Varna region in the north-west was only at its half at the end of the year, its lowest level in decades. Also Tsenovo dam in northern Bulgaria was at only 40% of its total volume which is only 33% of its total useful volume [4]. Hydrological drought conditions continued over autumn months of 2019 and gradually spread across the country in winter 2020 as rivers had significantly reduced water levels [5]. In November, water level of Studena Dam in Pernik region in western Bulgaria was only at 25 % of its full volume, and in final weeks of 2019 Pernik region was in emergency state due to lack of drinking water [6, 7]. The flow of Maritza and Tundzha rivers in Plovdiv region in central Bulgaria also more than halved by the beginning of 2020, starting to form sand islands along the riverbed [8]. At the same time, in Dobrich in northeastern Bulgaria, approximately a third of all oilseed cultivation areas collapsed due to drought periods over the year and snow-free winter prior to it [9].

TURKEY

Bayındır Lake in central-northern Turkey, one of the most important haunting areas of the flamingos in that part of Turkey, has completely dried up in June. The living spaces of flamingos are also decreasing with gradual drying up of the lake [10]. Also in June, Tunca and Meric rivers in European part of Turkey bordering to Bulgaria and Greece experienced the lowest water flow in recent years, even though they are normally known for flooding. Waters were withdrawn and giant sand islets formed. However, both rivers used for irrigation of agricultural lands, especially during periods of drought [11, 12].

[1] https://moldova.europalibera.org/a/30081622.html
[2] https://moldova.europalibera.org/a/30112518.html
[3] https://stirileprotv.ro/stiri/actualitate/zonele-din-romania-cu-seceta-extrema-fermierii-disperati-caldurile-au-fost-naucitoare.html
[4] https://www.dnevnik.bg/ot_vas/novini_ot_vas/2020/01/29/4022165_susha_i_v_iztochna_bulgariia/
[5] https://www.dnevnik.bg/ot_vas/novini_ot_vas/2020/01/31/4023398_susha_prez_zimata/?pic=3
[6] https://www.dnevnik.bg/bulgaria/2019/12/23/4009262_v_pernik_se_obmislia_uduljavane_na_bedstvenoto/
[7] https://www.24chasa.bg/novini/article/7854085
[8] https://www.24chasa.bg/novini/article/8121051
[9] http://www.bta.bg/bg/c/BO/id/2046011
[10] https://www.sabah.com.tr/akdeniz/2019/07/14/kuru-goller-bolgesi
[11] https://www.sabah.com.tr/video/yasam/taskinlarla-bilinen-tunca-ve-merici-kuraklik-vurdu
[12] https://www.aa.com.tr/tr/turkiye/tunca-nehrinin-yatagi-temizleniyor/1542378

Methodology

Drought monitoring bulletin is based on numerical weather prediction (NWP) model simulations over SE Europe, SPI index calculations and remote sensing. Precipitation data is provided by Global Precipitation data Centre (GPCC; gpcc.dwd.de), using a 50-year reference period between 1951-2000. NWP simulations are performed with Non–hydrostatical Meso–scale Model (NMM, see: http://www.dtcenter.org/wrf–nmm/users/). Historical DMCSEE model climatology was computed with NMM model for time period between 1st January 1986+ and 31st December 2015. European Centre for Medium Range Weather Forecast (ECMWF) ERA–Interim data set (see: http://www.ecmwf.int/en/research/climate–reanalysis/era–interim) was used as input for simulations. Long term averages (1979–2016), used for comparison of current weather conditions, are obtained from simulated data set. Comparison of current values to long term averages provides signal on potential ongoing drought severity.