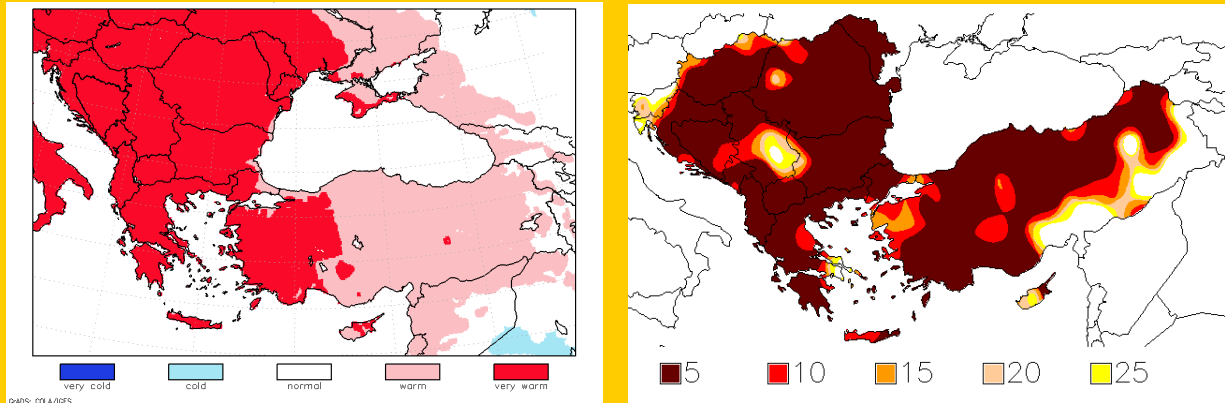


# DROUGHT MONITORING BULLETIN

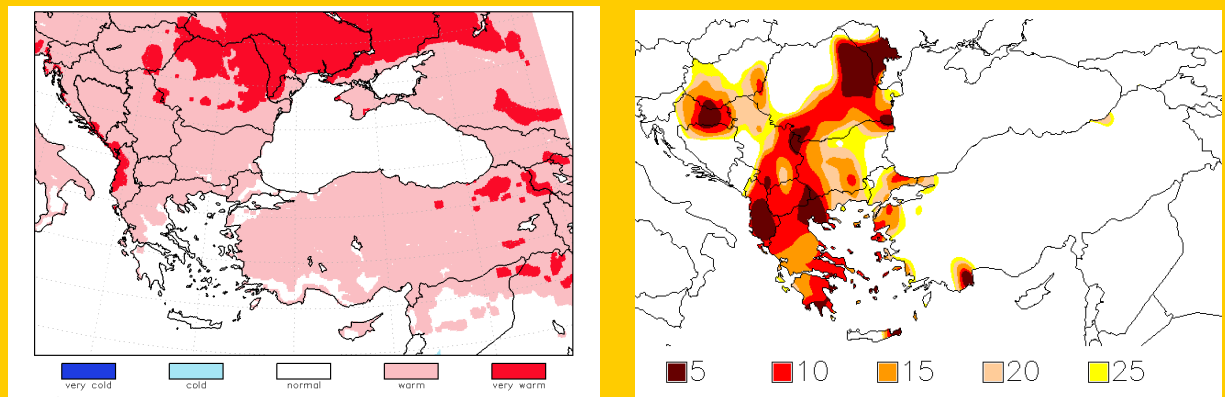
*Overview from January to November 2018*

## HOT SPOT



**April 2018: mean monthly air temperature in percentile classes with reference period 1981-2010 (left) and precipitation percentiles with reference period 1951-2000 (right).**

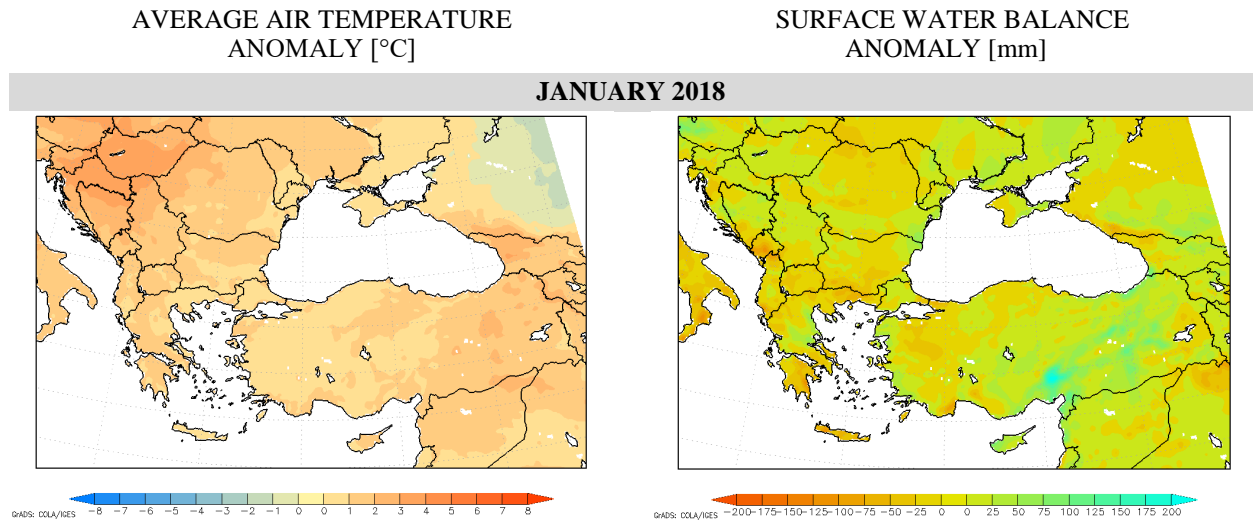
While this year central and northern Europe dealt with extremely dry conditions mainly over the summer months, southeastern Europe experienced warmer and drier than usual spring and autumn months. April brought air temperatures well above the average across vast part of the region, later in month they stretched as high as 26-28 °C, in many places even 30 °C. Much warmer than usual was also October when monthly mean temperature exceeded the long-term average for up to 2 °C all across the region, over its northern part and northern Turkey for even up to 3 °C. At the same time, the region recorded also evident lack of rain. In April, monthly rainfall rate classified among the lowest 5<sup>th</sup> percentile of local 50-year record across most parts of the region. Similar situation appeared also in October when scarce precipitations, this time ranked among the lowest 20<sup>th</sup> percentile, hit mostly Balkan Peninsula. Spells of warmer weather resulting in high evaporation, combined with noticeably reduced precipitation level created dry conditions across the region both in spring months, persisting mostly across Turkey, and in autumn months, persisting mostly over Balkan Peninsula.



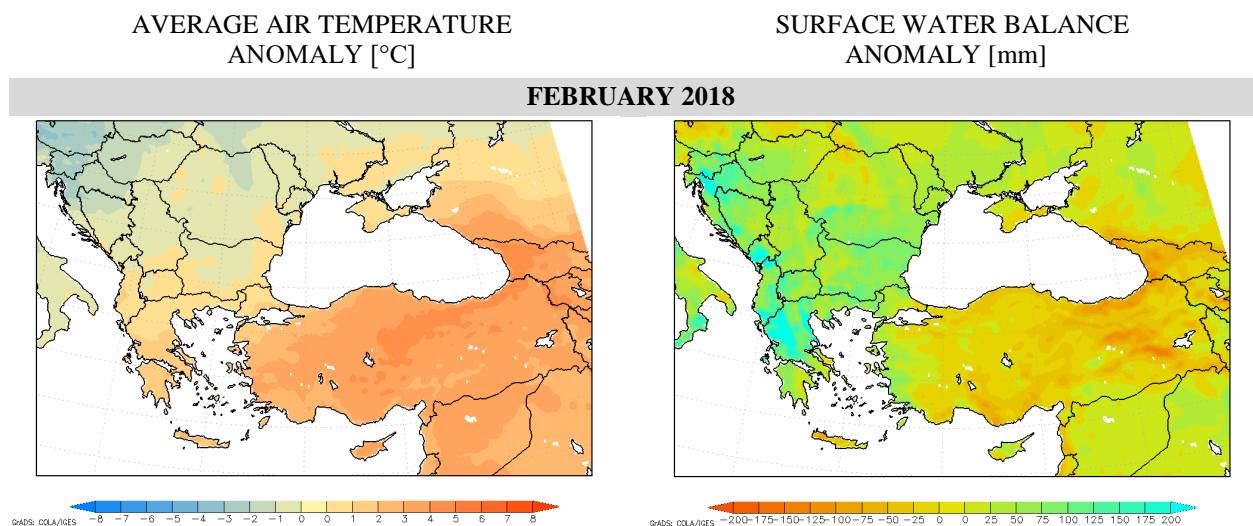
**October 2018: mean monthly air temperature in percentile classes with reference period 1981-2010 (left) and precipitation percentiles with reference period 1951-2000 (right).**

## AIR TEMPERATURES AND SURFACE WATER BALANCE

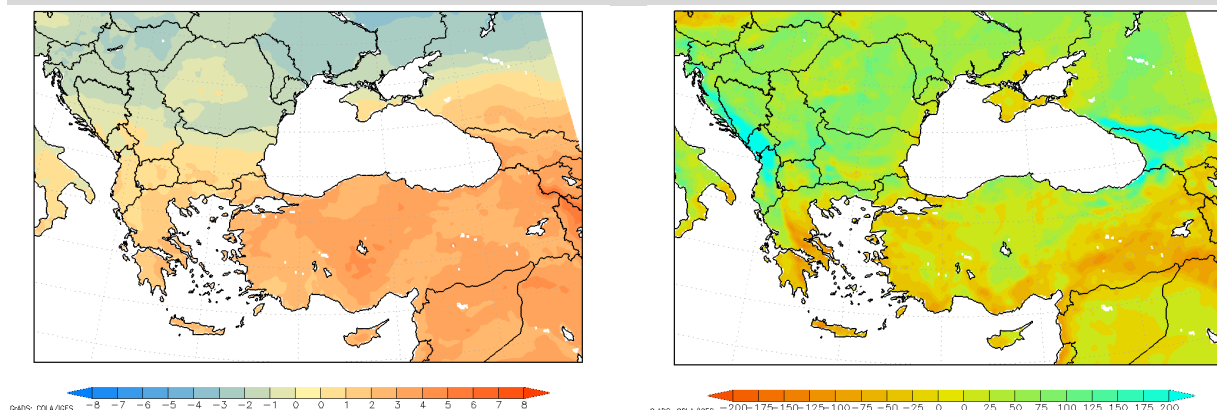
Figures in this section present anomalies from the average of 1981-2010 period of monthly *air temperature* and accumulated *surface water balance* from *January to November 2018*.



Beginning of the year was much warmer than usual across all region. In first 10 days of **January**, air temperatures exceeded the average for 2–3 °C in Greece and Turkey while in northern half of Balkan Peninsula anomalies stretched 4–6 °C above the average, in continental Croatia and Hungary even up to 7 °C, which classified them among hottest 5% of historic records for this time of year. Throughout January, air temperatures remained above-average over northwestern Balkan Peninsula and eastern Turkey while anomalies declined in belt area from Moldova to Greece and western half of Turkey and dropped up to 2 °C below the average later in month. Nevertheless, also on monthly scale January was warmer than usual for up to 2 °C over the region while over its northwestern part monthly mean was up to 4 °C above the average. Accompanied high evaporation was mostly balanced out by January precipitation level, leaving surface water balance across the region range about normal values. Noticeable surplus was present only in mountainous area of southeastern Turkey, of 75–150 mm, while much drier than normal were Montenegro, southern Albania and Aegean parts of Greece with water balance deficit between –75 mm and –125 mm.



**MARCH 2018**



Much warmer than usual were also first days of **February** as mean air temperature was 2–4 °C higher than normally over Balkan Peninsula with exception of its far northern belt, and up to 6 °C higher across central Turkey. Warmer-than-usual air temperatures, although to a smaller scale, persisted over Turkey throughout the month, leaving February 3–4 °C warmer than usually across most of the country. Also precipitation level was scarce with exception of Aegean part of Turkey which, combined with high evaporation, resulted in surface water balance deficit especially in eastern half of Turkey, between –75 mm and –150 mm. On the other hand, most of Balkan Peninsula down to northern Greece was hit by extremely cold spell in late February which brought air temperatures 3–6 °C lower than normally, locally in Croatia and over the Carpathians even up to 8 °C lower than normally for that time of year. Intense drop of temperatures left February colder than usual on monthly scale over northern half of Balkan Peninsula while, due to warmer beginning of the month, February mean was up to 2 °C higher than normally over its southern half. As accumulated precipitation level in February classified among wettest 30% of the record across entire Balkan Peninsula, countries experienced wet month with water balance surplus between 50–125 mm, in central Croatia, Montenegro and central Greece even over 175 mm.

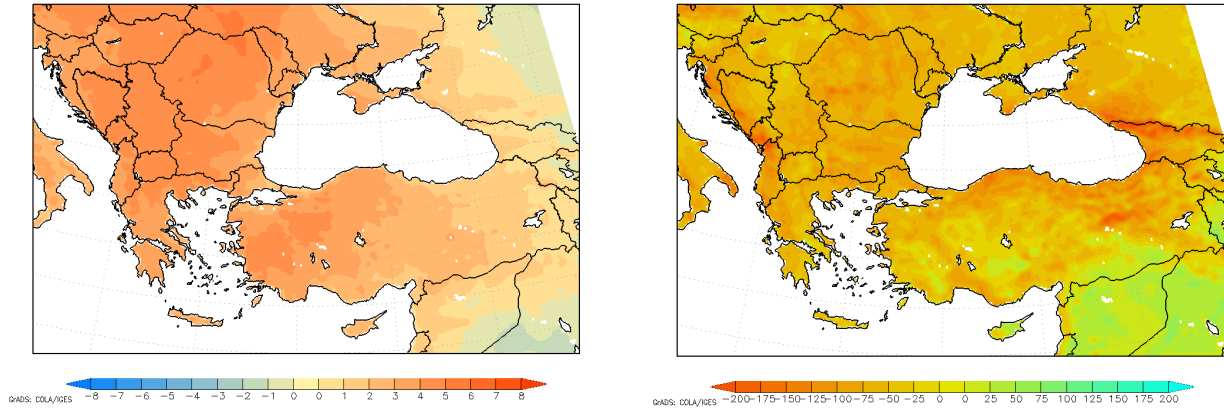
In northern parts of the region, from Croatia to Moldova and southern Romania, below-average air temperatures of late February persisted throughout **March**, leaving the area experience another colder-than-usual month, for up to 3 °C colder on monthly mean. Over southern half of Balkan Peninsula, air temperatures in first half of March were again 2–4 °C above the average and, despite colder spell experienced by northern areas stretched now over its south in final days of the month, mean March temperature was still up to 2 °C above long-term average over Albania, FYR Macedonia, most of Bulgaria and Greece. On the contrary, air temperatures over Turkey remained well above the average also in March, between 2–4 °C on monthly mean. Very high evaporation over Turkey and Greece along with only normal to low precipitation level along their southern parts resulted in negative water balance with monthly deficit of up to –125 mm over eastern and southern Greece and all along southern Turkey. The rest of the region received precipitation amount much higher than normally, resulting in monthly water balance surplus up to 100 mm across the area, along southeastern Adriatic coast even more than 200 mm.



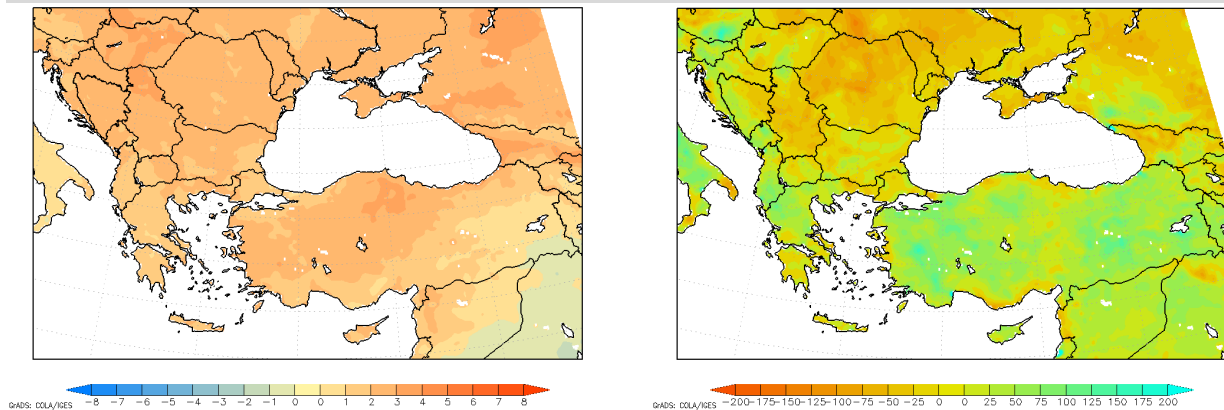
AVERAGE AIR TEMPERATURE  
ANOMALY [°C]

SURFACE WATER BALANCE  
ANOMALY [mm]

APRIL 2018

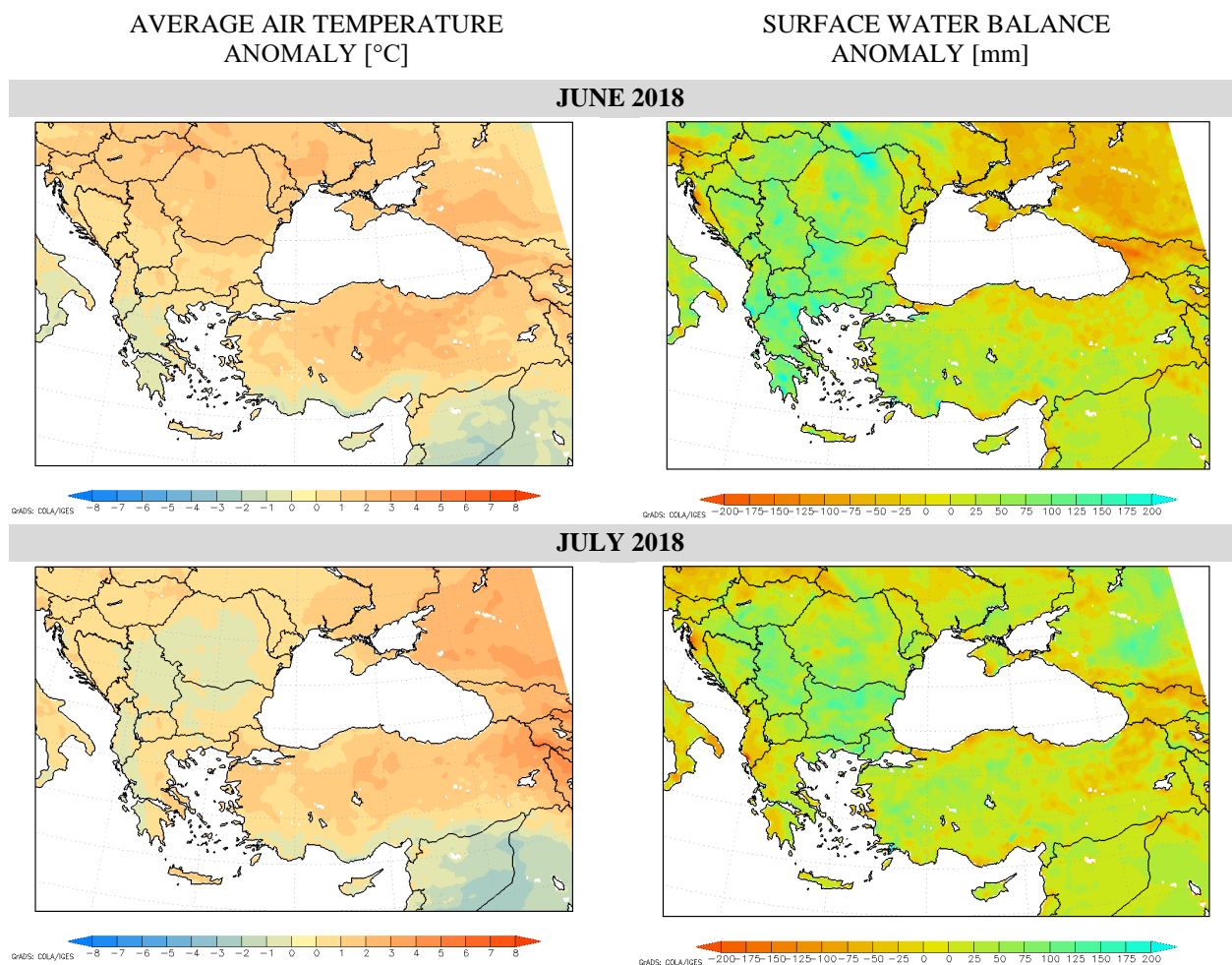


MAY 2018



After the cold spell was over by the end of March, air temperatures much higher than usual came to the region in first days of **April**: as they mostly remained up to 4 °C higher than normal over Turkey, anomalies over the rest of the countries suddenly rose from up to -3 °C below the average in late March, in wider lower Danube area from up to -4 °C, to 2-3°C warmer than usual in early April. Throughout the month, temperatures over far eastern Turkey gradually decreased to normal values while across the rest of the region they continued to rise even higher, exceeding the local mid-April average for up to 5 °C in Slovenia, coastal Croatia, Greece and central Turkey, even higher over wider central Balkan Peninsula and western Turkey, up to 6 °C, and for up to 7 °C in eastern Hungary and northern Romania. Situation remained almost unchanged also later in month, meaning April mean air temperature was among the hottest 5% of the record all across Balkan Peninsula and western third of Turkey. On monthly scale, April was up to 4 °C warmer than usual in Slovenia, Croatia and coastal belt from Moldova to Greece, and up to 5 °C warmer over region's continental areas. Consequently, accumulated evaporation was also among the highest 5% of the record across all region except central Turkey. At the same time, precipitation level was very scarce, along region's western coastline, eastern Balkan Peninsula and central and northeastern Turkey rainfall rate was one of the lowest recorded for that time of year. All combined created favourable circumstances for development of extremely dry conditions across the region: southern part of Turkey was the only area ending a month with surface water balance surplus but which did not exceed 50 mm; elsewhere, accumulated water balance deficit ranged mostly between -75 mm and -125 mm although highest deficit of up to -200 mm was present along southeastern Adriatic Sea, southern Carpathians and northeastern Turkey.

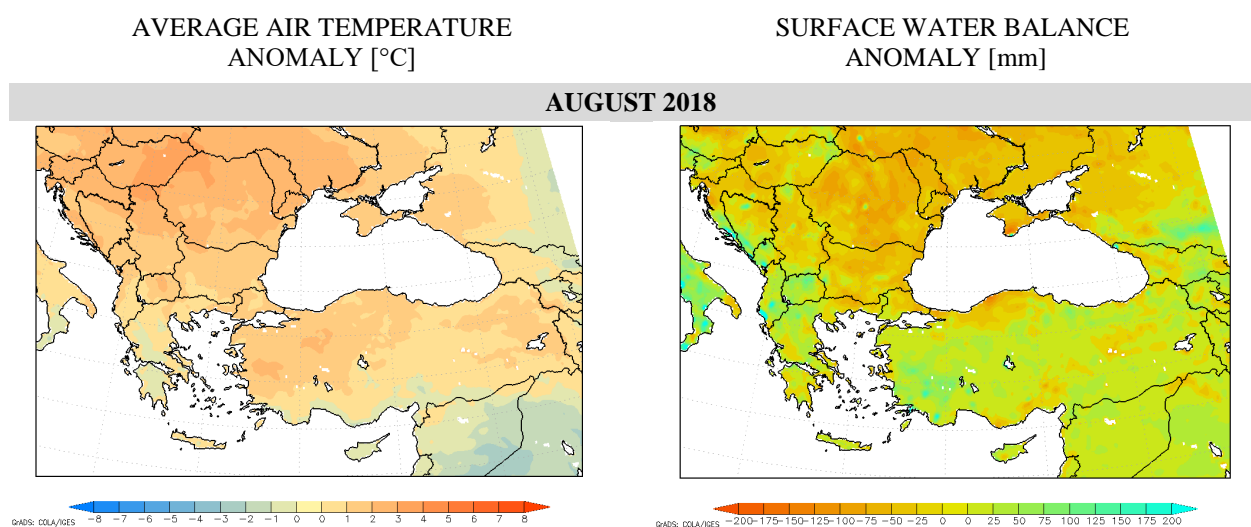
As **May** arrived, area of highest anomalies moved eastward to Moldova, leaving Albania, FYR Macedonia, Greece and southwestern Turkey experience above-average temperature anomalies now almost three degrees lower compared to late-April situation. On the other hand, anomalies in early May rose up to 6 °C over northern Turkey, western Hungary and northern Romania, in Moldova up to 7 °C. Spring spell of hot weather came to an end in mid-May when air temperatures dropped back to normal values all across northern half of Balkan Peninsula and eastern Turkey, lowest anomalies of up to 3 °C were present only across wider Aegean Sea area. Another wave of warmer temperatures came again in late May when deviations of 3–4 °C from the average spread over wider central Turkey and areas northwestern of a belt from Albania to northern Romania. On monthly average, May too was much warmer than usually: across central Balkan Peninsula from Hungary to Aegean Sea and central Turkey monthly mean of 3–4 °C above the average classified among hottest 5% of local records while elsewhere monthly mean stood up to 2 °C higher than normally. Unlike April, May brought favourable precipitation level to Turkey, Greece and countries along the Adriatic Sea which resulted in positive monthly surface water balance between 75–100 mm, locally in western and eastern Turkey even up to 150 mm. On the other hand, Serbia, Romania and Moldova experienced another dry month and ended a month with accumulated water balance deficit between –50 mm and –100 mm, over southern Carpathians up to –125 mm.



Warm spell from late May intensified in early **June** and spread over all countries of Balkan Peninsula: Aegean Turkey and entire Balkan Peninsula experienced air temperatures up to 4 °C warmer than normally for this time of year; over the Great Plain lowlands in Hungary, Croatia and Serbia they stretched up to 5 °C above the long-term average and exceeded 30 °C. By the end of

the month, temperature anomalies over eastern Turkey gradually increased from usual values to 3–4 °C higher than normally while they rapidly decreased over the rest of the region and dropped to 2 °C below the average over belt area from Hungary to western Turkey and up to 4 °C below the average over central Croatia and most of Greece. Western half of Balkan Peninsula thus classified among coldest 30% of the record in late June; in some places along the Adriatic Sea air temperatures as low as 14 °C were recorded. Due to much colder than usual end of June, monthly mean ranged about average values over southern half of Balkan Peninsula and Mediterranean Turkey. However, much warmer than usual first half of June contributed to monthly temperature mainly 2 °C higher than the average from Slovenia to Romania and over most of Turkey. After dry spring months, June brought unusually high level of precipitations across the region, especially to Albania and Greece. Although in certain parts such as Slovenia, coastal Croatia, western Black Sea coastline and northeastern Turkey surface water balance ended up in deficit of up to –75 mm, accumulations of June water balance resulted in noticeable surplus ranging between 50–125 mm over Turkey and most of northern Balkan Peninsula, and between 125–200 mm over Greece, Albania, FYR Macedonia, western Bulgaria and northern Carpathians.

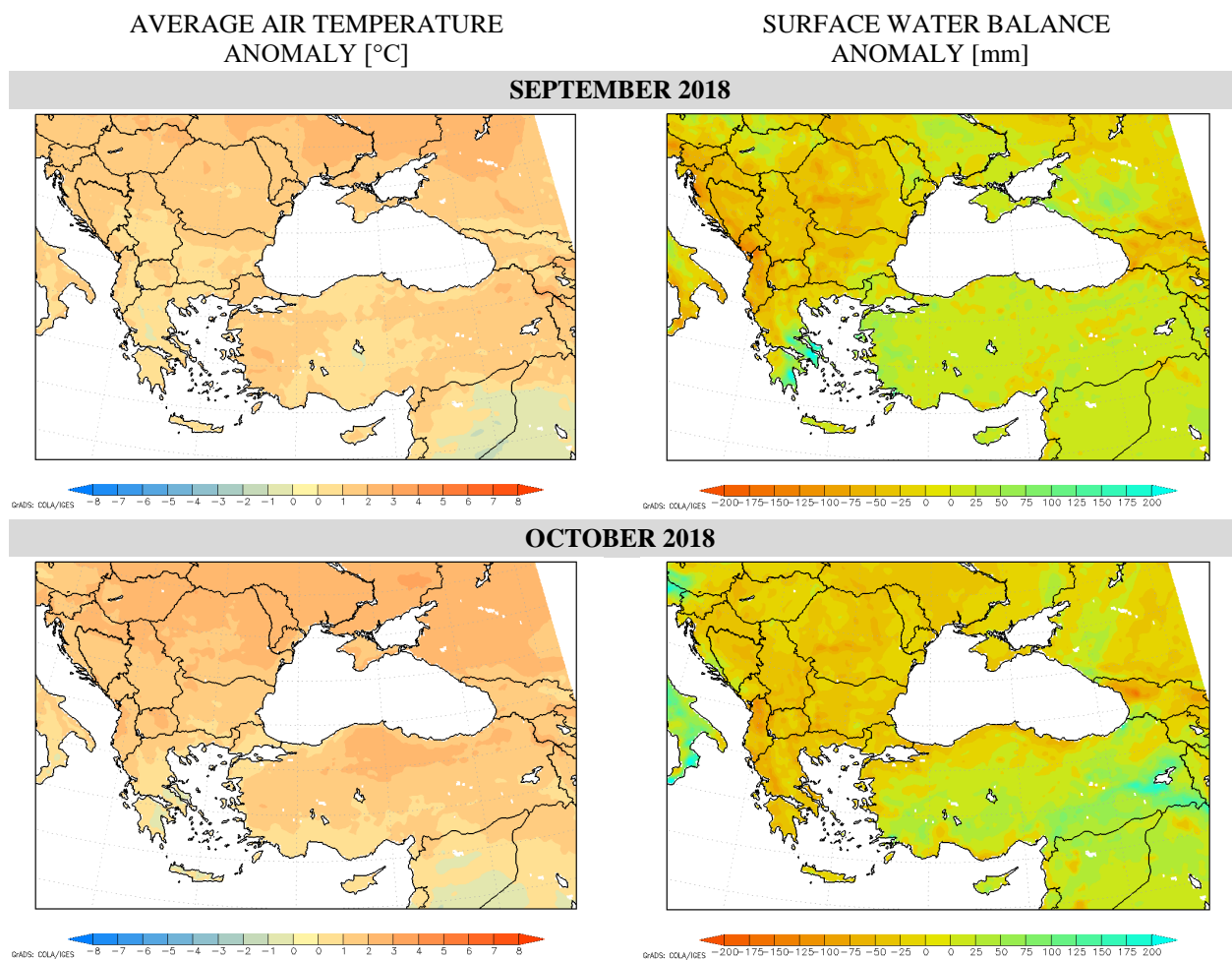
After a range of strong fluctuations, **July** air temperatures were more or less stable throughout the month. In first days of July, they were up to 4–5°C warmer than normally in far eastern Turkey and up to 2 °C colder than normally in area from Slovenia to Moldova and southern Serbia. Strong anomalies in either extremes did not last long: anomalies soon dropped to 3 °C above the average over Turkey and mostly normalized elsewhere in the region by mid-July and remained so until the end of the month, except for Albania, western Greece and all along southern Turkey where temperatures dropped up to 2 °C below the average in late July. On monthly mean, July was up to 2 °C warmer than usual across most of Turkey while elsewhere in the region deviations from the average were minimal. July too brought high amount of precipitation to the region and, in addition to June surplus accumulations, ended up with another 50–125 mm of water balance surplus over most of Balkan Peninsula and Turkey. Wettest conditions with surplus of up to 175 mm were present over central Serbia and Bulgaria. Exception to the wet conditions were areas in a belt from Slovenia to southern Greece and eastern half of Turkey where normal to dry conditions prevailed and monthly surface water balance resulted in deficit mostly between –50 mm and –100 mm, locally in coastal Croatia and southern Albania even up to –175 mm on monthly total.



Warmer-than-usual air temperatures spread over most of the region again in **August**. Greece and southern coastal Turkey, however, escaped warm spell and continued to experience deviations of



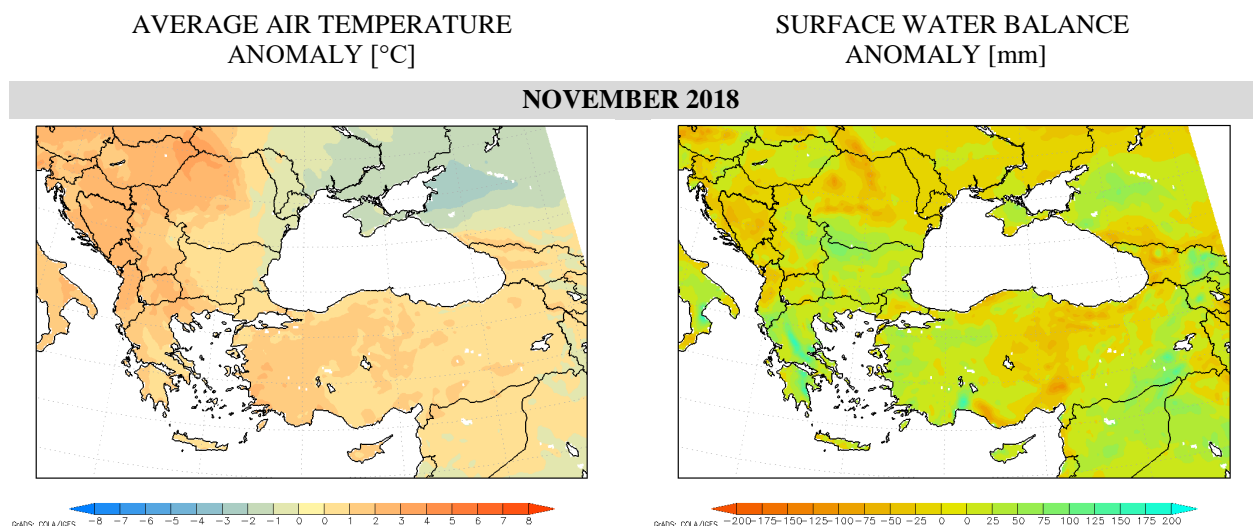
-1 °C to 1 °C from normal temperatures throughout all month. As anomalies of 3–4 °C above the usual temperatures first appeared over Slovenia, Croatia and Hungary, they spread over wider part of northern Balkan Peninsula by mid-August and finally stretched across entire northeastern quarter of Balkan Peninsula, from Hungary to Moldova and Bulgaria, and all across continental Turkey by the end of the month. Continuously warmer than usual air temperatures throughout the month reflected also in monthly means: across wider belt area from Bosnia and Herzegovina across Bulgaria to western half of Turkey, August mean temperature was up to 2 °C higher than normal while countries northeast of it experienced up to 3 °C warmer August than usually. With monthly mean up to 4 °C higher than long-term average, wider border area between Hungary, Romania and Serbia experienced this year's August as one among the hottest 5% of local historical record. After two mostly wet months across the region, dry conditions appeared again in August over vast area from northern and eastern Balkan Peninsula across to northern Turkey where surface water balance deficit from -50 mm to -75 mm prevailed, across most of Romania, Moldova and northern Turkey even up to -125 mm. High precipitation level was limited mainly to parts along southern Adriatic Sea, FYR Macedonia, Greece and western Turkey where excessive rainfall rate resulted in water balance surplus of up to 100 mm, locally along southern Adriatic coastline up to 150 mm.



Unusually warm conditions persisted as **September** arrived and spread also to southern parts of the region, including western Greece and Mediterranean Turkey. On average, first week of September was 2–3 °C warmer than usual in countries all along the Adriatic Sea, over Aegean Sea area and southern half of Turkey while they stretched 4–5 °C above the average over the rest of the region, from central Hungary and Moldova to northern Greece and all across northern half of

Turkey. Mid-September saw period of above-average air temperatures come to an end in Turkey, anomalies from the average dropped from 3 °C to –2 °C in its southwest and mostly normalized elsewhere across the country. While warm spell slightly eased over eastern Balkan Peninsula, it intensified across its northwestern part, with anomalies of up to 5 °C. By the end of the month, air temperatures normalized or dropped just below the average all over Balkan Peninsula and northern Turkey. Despite noticeable contrast between hot first half of the month and colder end of it, September was warmer than usual across the region with monthly mean mostly not more than 2 °C above the average. Except for southeastern Greece where extremely wet month resulted in monthly water balance surplus of 150–175 mm, and near-average rainfall rate across Turkey, September brought precipitation deficit to the rest of the region. Monthly water balance ranged mainly from –25 mm to –100 mm while deficit was the highest along Adriatic coastline, up to –150 mm.

In first week of **October**, air temperature anomalies dropped even lower below the average across Balkan Peninsula, mostly up to –2 °C, in Hungary and central Greece up to –3 °C. While air temperatures remained colder than usual in southern Greece in mid-October, anomalies increased noticeably in countries northern of it and indicated temperatures much warmer than normally for this time of year: in vast area from FYR Macedonia to Croatia and Moldova they were 2–3 °C higher than usual, and up to 4–5 °C higher over Hungary and northern Romania. By that time, they rose well above the average also across Turkey as they exceeded the average for up to 3 °C over its west and south and between 4–5 °C over its northern and eastern part, bringing air temperatures among the highest 5% of local record. Intensity of higher-than-normal air temperatures decreased later in month as they normalized across most of Turkey, however they remained up to 2 °C higher than late-October average across northern Turkey and southern half of Balkan Peninsula, and up to 3 °C higher over its northern areas from southern Romania and Moldova to Slovenia and northern Croatia. Despite initial colder than usual air temperatures, October was another warm month in the region; monthly mean of up to 3 °C above the long-term average classified this year’s October among the hottest of local historic records in area from Moldova to eastern Hungary and in parts along southern Adriatic Sea and northeastern Turkey. Elsewhere across the region with exception of southern Greece, October was up to 2 °C warmer than normally. Even in terms of surface water balance, October brought unfavourable conditions and continued the dry spell over Balkan Peninsula. Precipitations were sufficient across central Turkey and even excessive over its south-east, resulting in water balance surplus of 100–150 mm. However, lack of rain over the rest of the region left surface area in water balance deficit of –25 mm to –75 mm, over the Carpathians, Albania and western Greece up to –125 mm, in addition to dry August and September.



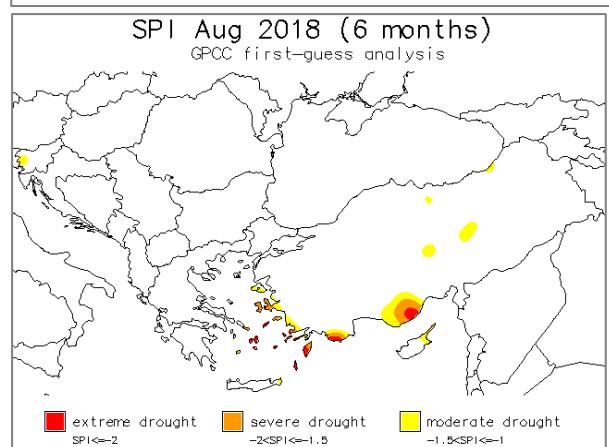
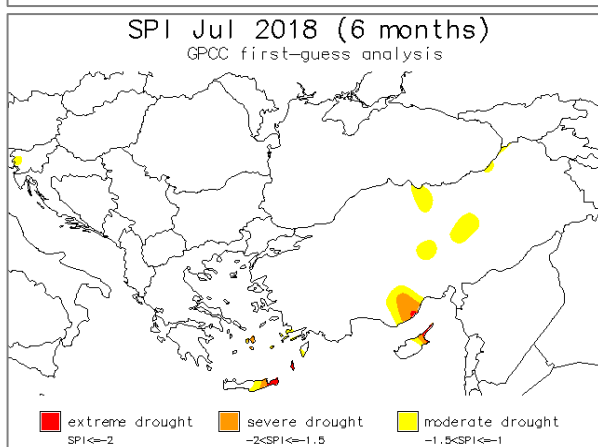
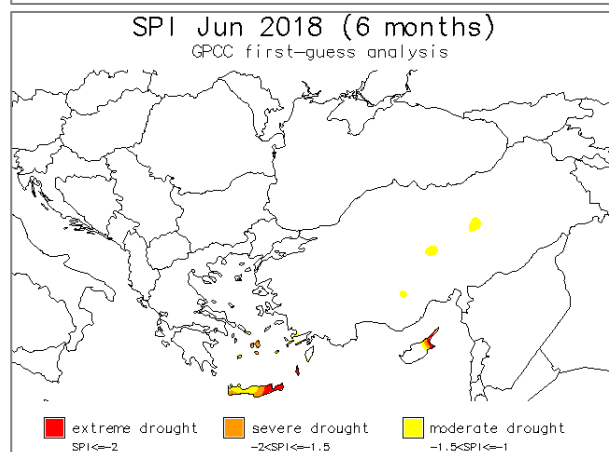
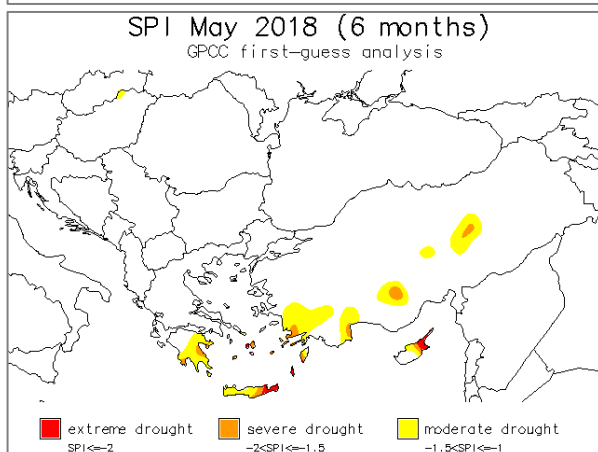
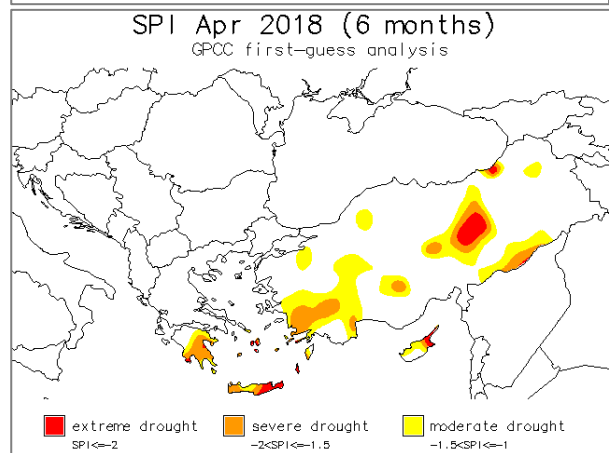
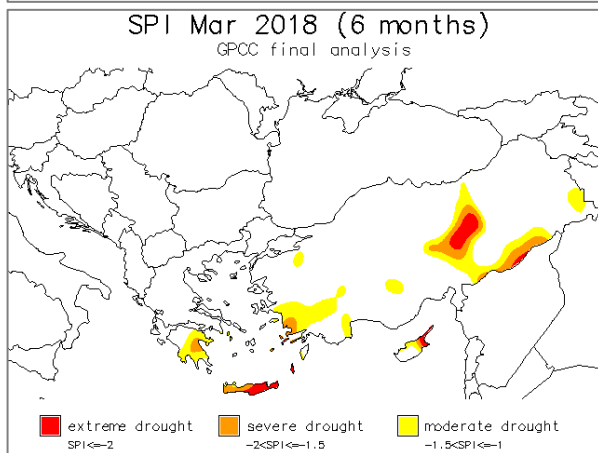
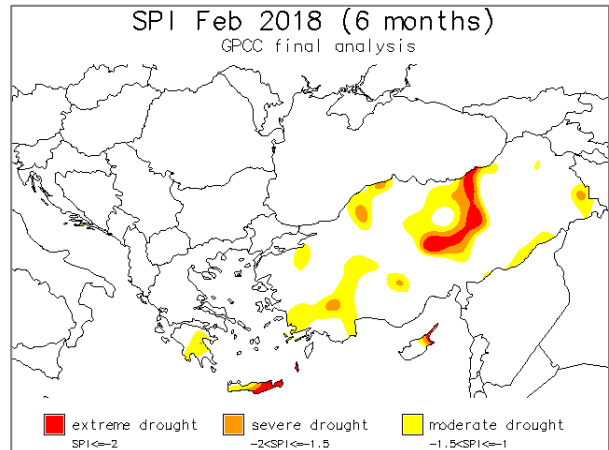
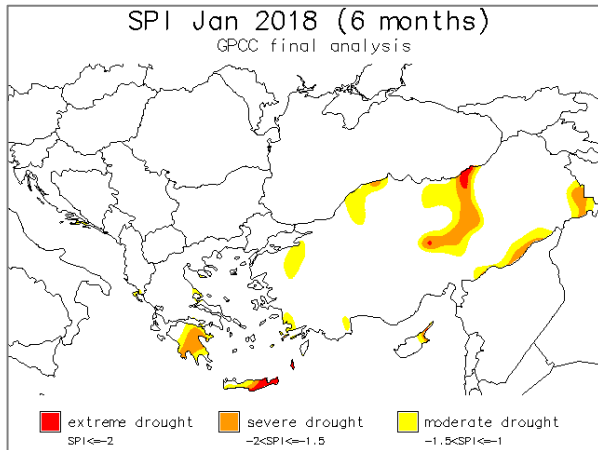


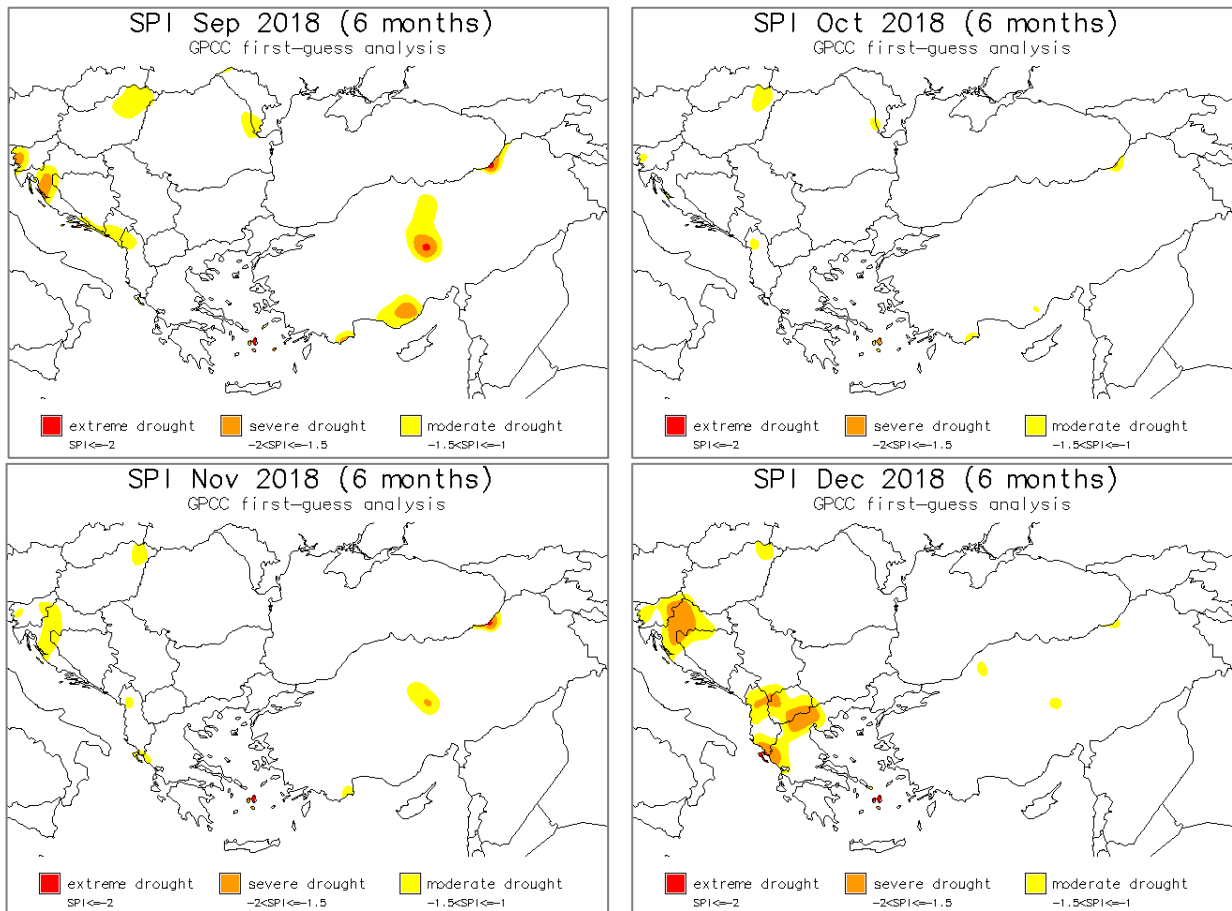
Air temperatures, already warmer than usually at the end of October, rose even higher above the average in early **November**: 10-day anomalies ranged from 2–3 °C across south-west to north-east of Turkey, 4–5 °C over its northwestern part and over Greece, up to 7 °C warmer than usual across northern Bulgaria, FYR Macedonia, Serbia to Slovenia, and even up to 8 °C and higher above the average in vast area from eastern Hungary and northern Serbia to Moldova. As air temperatures mainly returned to average values over Greece and Turkey in mid-November, anomalies still stood well above the average in northwestern Balkan Peninsula, between 4–5 °C, and between 2–3 °C higher over its central area stretching across Montenegro, Serbia, FYR Macedonia and southern Romania. Air temperature anomalies of last decade of November indicated another warm spell came to an end as across northeastern half of Balkan Peninsula from Slovenia to southern Bulgaria air temperatures of up to 2 °C colder than usual prevailed, across Moldova and coastal Romania up to 4 °C colder. Meantime, above-average values up to 2–3 °C were present only along southern Adriatic coastline and over Greece. Although characterised as another month with significant air temperature deviations in either extremes, November too was warmer than usual across most of the region: in northern and western parts of Balkan Peninsula monthly mean exceeded the average for up to 3 °C while over Greece, Bulgaria and Turkey anomalies ranged from 1–2 °C. On the other hand, mean November temperature was up to 1 °C lower than normally over Moldova, first time since July that under-average monthly mean was detected across majority of any country in the region. In terms of water balance, conditions improved over Greece, Bulgaria, Serbia and western and eastern Turkey but also eastern Hungary where higher than normal rainfall rate resulted in monthly water balance surplus of 25–75 mm, locally up to 125 mm. Elsewhere, in Moldova, most of Romania, western Balkans and across central Turkey, dry conditions continued, with additional monthly water balance deficit between –25 mm and –75 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 can tell us more about hydrological conditions throughout the year.





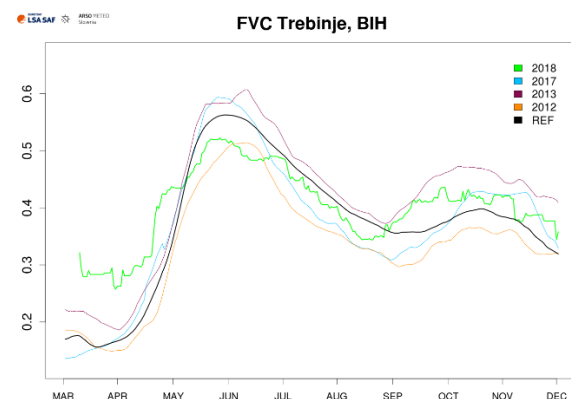
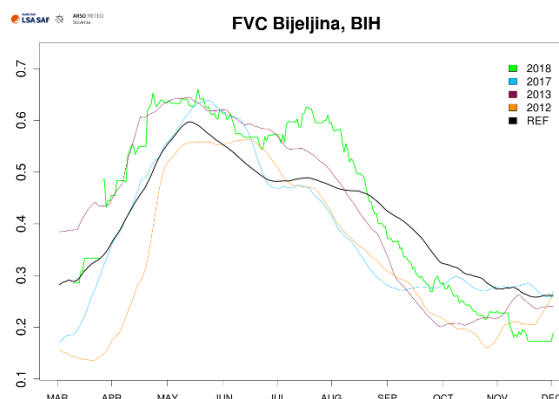
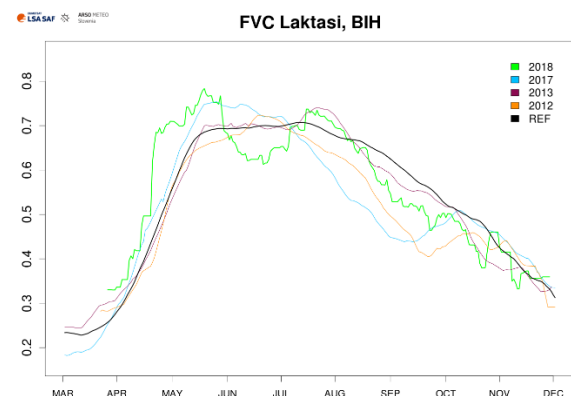
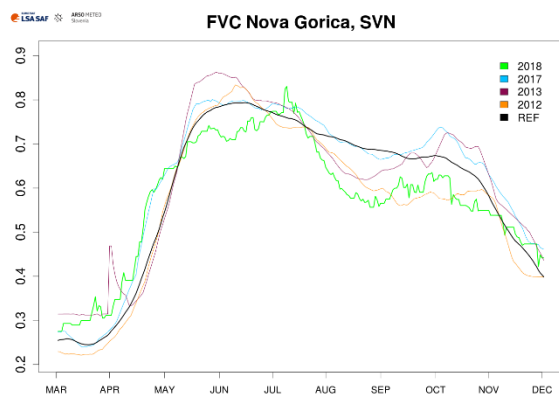
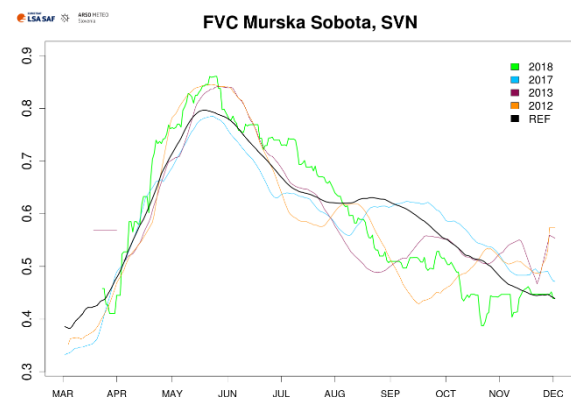
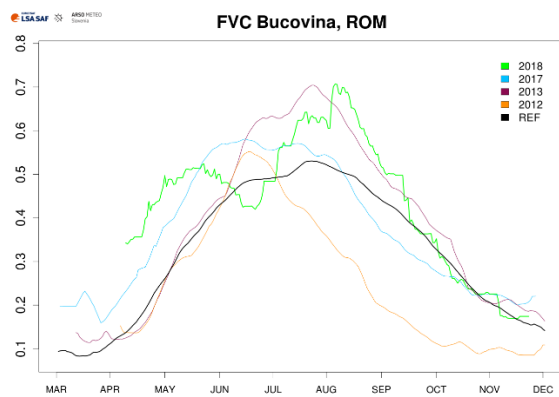
In general, first half of the year was characterised by drought conditions present mainly over southern half of the region, namely Greece, Cyprus and Turkey, while in second half of the year drought conditions appeared across Balkan Peninsula. From January to April, moderate to severe drought conditions persisted across scattered parts of Turkey and southern Greece while locally over central-eastern Turkey, Crete Island and eastern Cyprus extreme drought conditions prevailed. While intensity and spatial extent of dry conditions decreased over Turkey and southern continental Greece in May, and mostly returned to normal state in June, extremely dry conditions over Crete Island and eastern Cyprus only came to an end in August. SPI6 for August indicate intensifying of dry conditions again across Aegean Greece and southern Turkey to extreme level although it returned back to average conditions in autumn months. On the other hand, first signals of moderate drought over the Alpine area appeared in August and intensified to severe level throughout September. Low SPI6 values for September show moderate and severe drought conditions developed also locally across central third of Turkey but also across outer area of Balkan Peninsula – along the Adriatic Sea, eastern Hungary and southern Moldova. Situation slightly improved in October but SPI6 for November and December show worsening of dry conditions mostly across Croatia, Albania, FYR Macedonia and northern Greece where severely dry conditions developed.

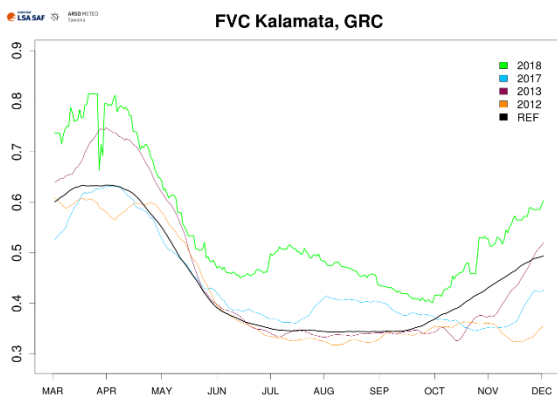
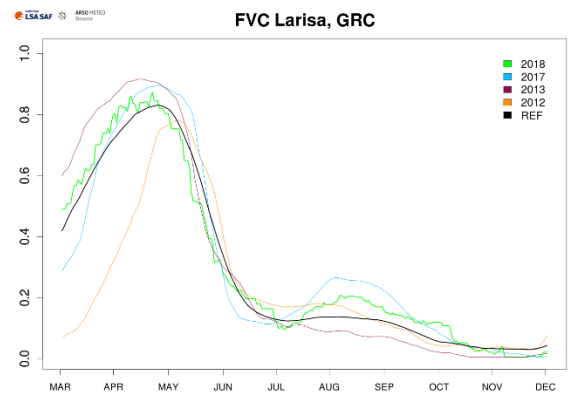
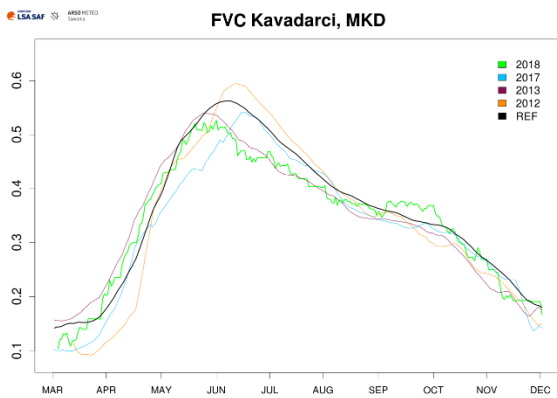
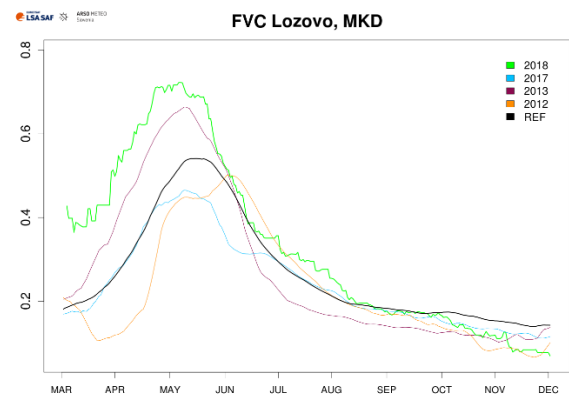
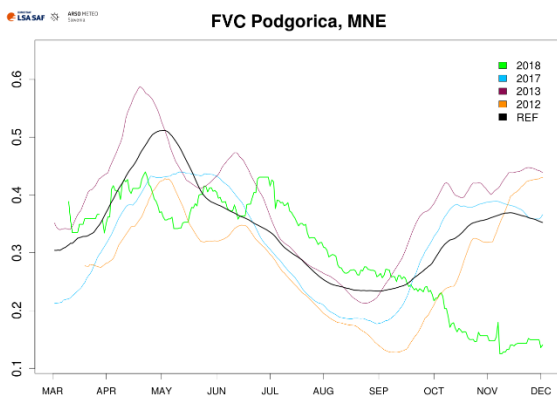
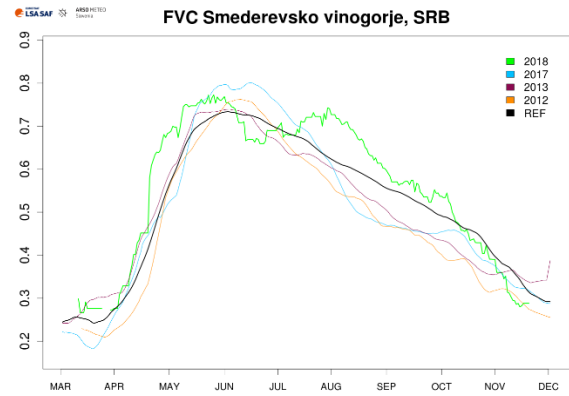
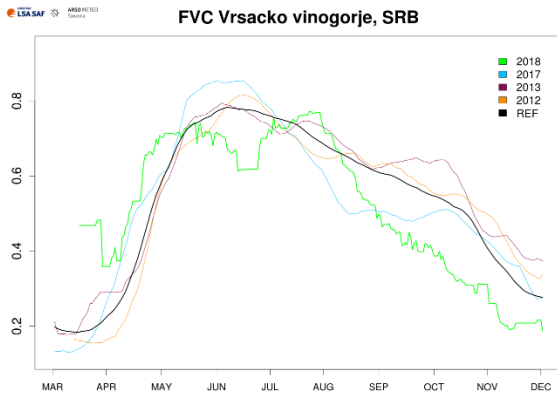


## REMOTE SENSING – FRACTION OF VEGETATION COVER

Fraction of vegetation cover (FVC) is vegetation index, based on multi-channel remote sensing measurements (data from Eumetsat's LSA SAF 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 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 2018** at 13 locations across Southeastern Europe, as indicated by FVC. FVC values for year 2018 are presented in green line. Graphs also include reference line (2004–2017) in black, and lines in light blue (year 2017), magenta (year 2013) and orange (year 2012) for comparison. Possible missing values or sharp decline could be a result of 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;
- Bosnia and Herzegovina – Laktaši, Bijeljina, Trebinje;
- Serbia – Veliko središte (Vršacko vinogorje), Malo Orašje (Smederevsko vinogorje);
- Montenegro – Podgorica;
- FYR Macedonia – Lozovo, Kavadarci;
- Greece – Larisa, Kalamata.

## IMPACT REPORTS

### MOLDOVA

Spring drought conditions left negative impacts on honey production where total yield in 2018 across Moldova was 15–20% lower than a year before. Mostly affected was production of acacia honey, reported also from Ocnîța district in northern Moldova as well as from Basarabeasca district in southern part of the country where acacia yield was more than halved compared to year 2017. In Basarabeasca, total yield was up to 30% lower than a year before [1].

### HUNGARY

Periods of persistent warmer-than-usual air temperatures and scarce or even no precipitations throughout the year heavily reduced water level in the Danube river. Affected also by this year's drought present further upstream in Austria and Germany, Danube hit historically low levels at several points across Hungary – in Budapest, for example, water level in mid-August dropped to 93 cm, exposing iconic “drought rocks” at the riverbed, and hit new record-low of 49 cm by mid-October, 2 cm lower than value set in 1947. Water level decreased further on, standing at 41 cm in mid-November [2, 3].

Low Danube levels failed to provide ideal navigable depth for shipping, causing major losses in transport: it reduced freight shipping capacity running across Hungary by almost two thirds and increased shipment prices by 15–20% [4, 5, 6, 7].

As a result of lowered Danube level now which heated up faster, Paks Nuclear Power Plant was forced to reduce its productivity in late August as water hit critical temperatures of 29.8 °C while legislation would require power plant to stop completely if water temperature exceeded 30 °C [8].

[1] <https://press.try.md/item.php?id=1042823128>

[2] [https://bbj.hu/energy-environment/water-level-in-danube-falls-to-record-low\\_156570](https://bbj.hu/energy-environment/water-level-in-danube-falls-to-record-low_156570)

[3] [https://www.napi.hu/magyar\\_gazdasag/kilatszok-az-inseg-szikla-a-dunabol-budapestnel.667898.html](https://www.napi.hu/magyar_gazdasag/kilatszok-az-inseg-szikla-a-dunabol-budapestnel.667898.html)

[4] <https://dailynewshungary.com/farmers-unable-to-shift-grain-due-to-low-danube-water-level/>

[5] <https://dailynewshungary.com/low-water-levels-cut-danube-freight-capacity-by-two-thirds/>

[6] [https://www.napi.hu/magyar\\_gazdasag/lebenult-a-szallitmanyozas-a-dunan.673609.html](https://www.napi.hu/magyar_gazdasag/lebenult-a-szallitmanyozas-a-dunan.673609.html)

[7] <https://www.reuters.com/article/us-europe-weather-hungary-shipping/water-levels-in-danube-recede-to-record-lows-hindering-shipping-in-hungary-idUSKCN1L71DH>

[8]

[https://index.hu/techtud/2018/08/25/ugy\\_felmelegedett\\_a\\_duna\\_hogy\\_kis\\_hijan\\_le\\_kellett\\_allitani\\_a\\_paksi\\_atomer\\_omuvet/](https://index.hu/techtud/2018/08/25/ugy_felmelegedett_a_duna_hogy_kis_hijan_le_kellett_allitani_a_paksi_atomer_omuvet/)

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### 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). NWP simulations are performed with Non-hydrostatic 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 1979 and 31st December 2017. 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.