GDO Analytical Report

Drought in southern Urals and Turan Depression October 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency

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Executive summary

- A large drought is affecting the regions within the southern Urals and the plains of Turan Depression on the north side of the Kope Dag and Hindu Kush mountain ranges. Countries involved are mainly Russia, Kazakhstan, Uzbekistan and Turkmenistan. Summer hot temperatures along with severe and persistent lack of precipitations affected agricultural crops and have increased wild and forest fire danger.
- Impact on soil moisture and vegetation has been wide and persistent in summer and it shows no signs of recovery. In the Russian Volga Federal District a declaration of a regional emergency due to drought was issued at the end of September. Increase of prices was recorded in the area for agricultural products and for livestock, due to fodder and transportation costs increase.
- Despite a slight improvement foreseen for the next month, drought conditions are expected to take longer to recover.

Risk of Drought Impact for Agriculture (RDrI-Agri)

The GDO indicator RDrI-Agri shows the risk of having impacts from a drought, by considering the exposure and socio-economic vulnerability of the area, with particular focus on agricultural impacts.

Meteorological conditions, better detailed in the following sections, have driven a large region to low and medium level Risk of Drought Impact for Agriculture (RDrI-Agri). As shown in Figure 1, the most affected areas are the southern part of Urals mountain range (bordering Turkmenistan and Iran) and the plains regions of Turan Depression at the north side of the Kopet Dag and Hindu Kush mountain ranges (Uzbekistan, Afghanistan and Pakistan). Countries involved are mainly Russia, Kazakhstan, Uzbekistan and Turkmenistan.

Most of the population is established in cities, agriculture predominates in the steppe region of the Southern Urals with favorable conditions for some crops. Also, the forest has relevant economic value for wood production, as well as ecological value[1]. In the Turan plains vegetation is sparse and the arid plain encompasses two deserts[2]. Total population living in the affected regions is about 35 million.

The extent is wide, despite not being simultaneously affected. Looking at the evolution of RDrI-Agri during the summer 2021, a large event emerges (see June and July panels in Figure 2). This situation improved only partially in early autumn 2021.

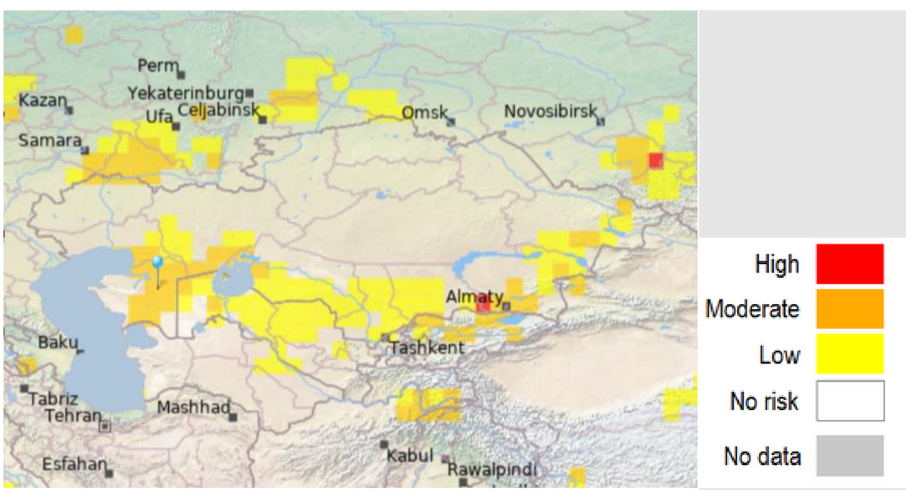

Figure 1: *Risk of Drought Impact for Agriculture (RDrI-Agri) – first ten days of October 2021.*

[1] https://www.britannica.com/place/Ural-Mountains

[2] https://www.britannica.com/place/Turan-Plain

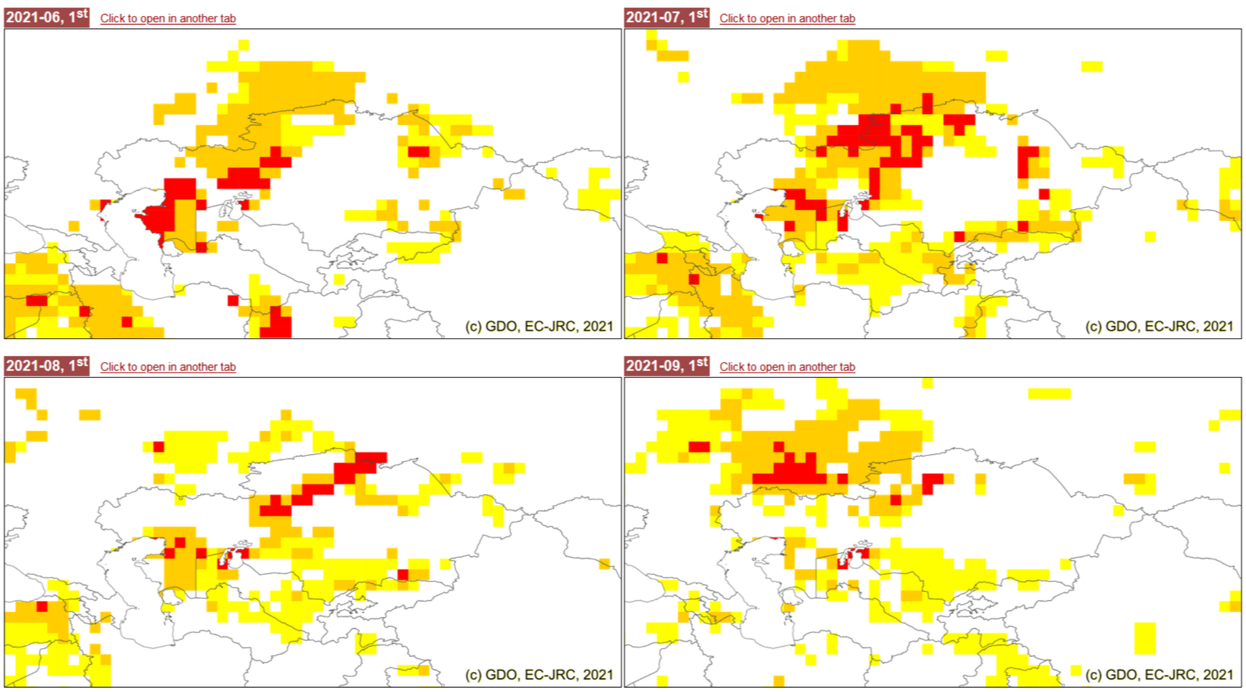

Figure 2: *Risk of Drought Impact for Agriculture (RDrI-Agri) – first ten days of each month from June 2021 to September 2021*

Considering geographical and climatological differences, we proceed analysing more in detail two of the main affected regions: Mangystau Region (Kazakhstan) in the plains east of the Caspian Sea and Orenburg Oblast (Russia) close to the southern part of Urals mountain range. These two selected regions are analyzed also in the next sections for each indicator.

The bar-chart (Figure 3) features a continuous rise of the RDrI-Agri from spring 2021 to middle summer and then reducing again in the second part of summer and beginning of autumn in Kazakhstan. Instead, in Southern Urals we observe a similar but more fluctuating pattern, with a delay of a couple of months and no drought signal in spring.

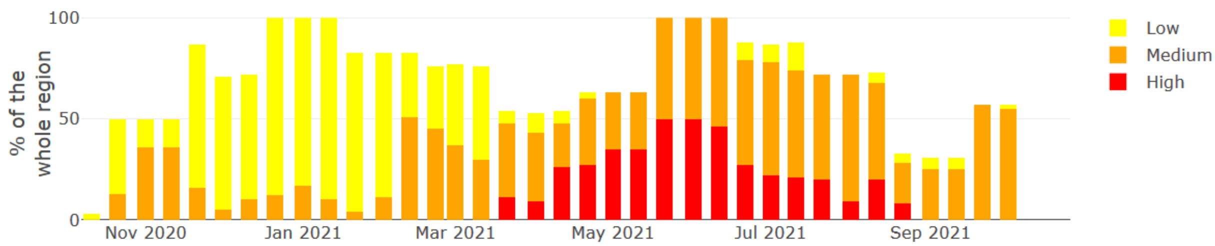

Figure 3: *Risk of Drought Impact for Agriculture (RDrI-Agri) - evolution over time for Mangystau Region (Kazakhstan) from the last ten days of October 2020 to the first ten days of October 2021*

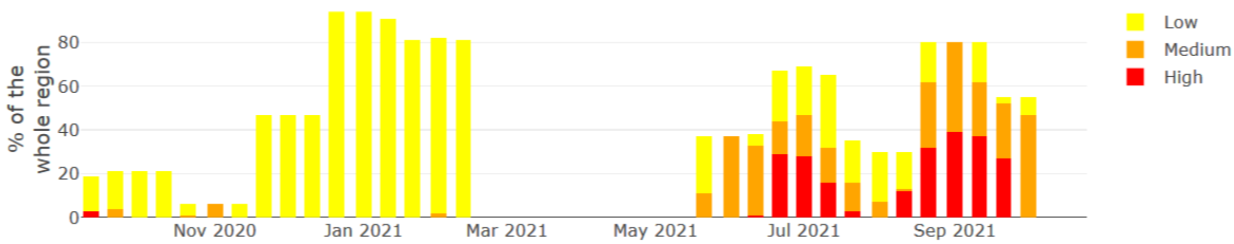

Figure 4: *Risk of Drought Impact for Agriculture (RDrI-Agri) - evolution over time for Orenburg Oblast (Russia) from the last ten days of October 2020 to the first ten days of October 2021*

Precipitation

Precipitation is measured by total monthly rainfall and snow and is the main component to understand drought events. The affected area is large enough to feature different climatic patterns.

In Kazakhstan the precipitation pattern of the last year features very high precipitation only in March 2021; except for this month precipitation are extremely scarce and the region is almost dry since April 2021 (figure 5). In southern Urals the situation is slightly better. Even if precipitation is generally below the long-term average (1981-2010) it is generally within normal fluctuations with severe lack of precipitation mainly in December 2020, May 2021 and August 2021 (figure 6). This produced a strong precipitation deficit in Kazakhstan, far below the long-term average, because of six months almost dry (only 7 mm of rain in from April to September 2021). In southern Urals instead only august 2021 was completely dry giving a strong deficit only in the las two months, however affecting the agricultural growth period.

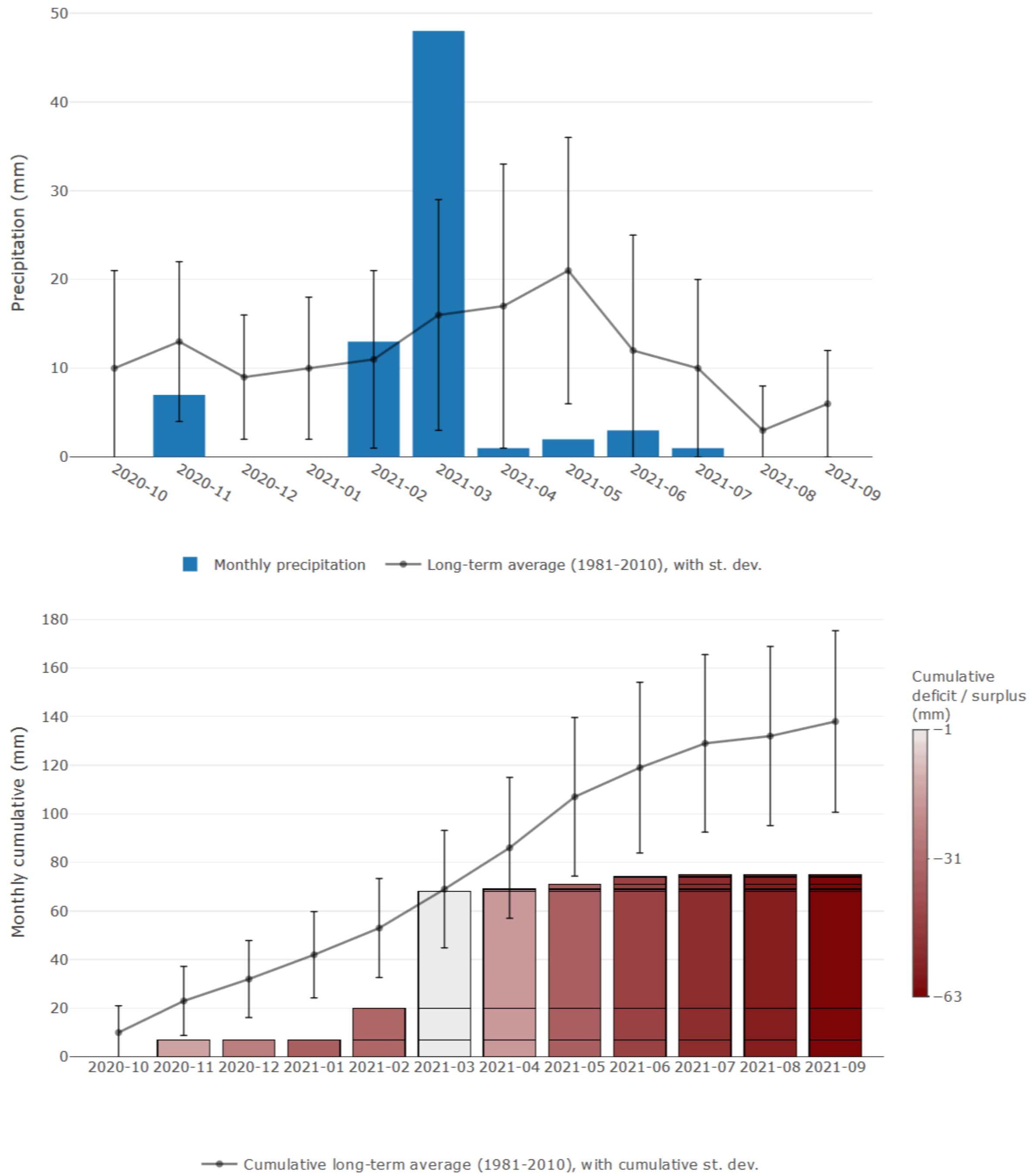

Figure 5: *Monthly total (upper) and cumulative (lower) precipitation - evolution over time for Mangystau Region (Kazakhstan) (44.4N, 54.7E) from October 2020 to September 2021*

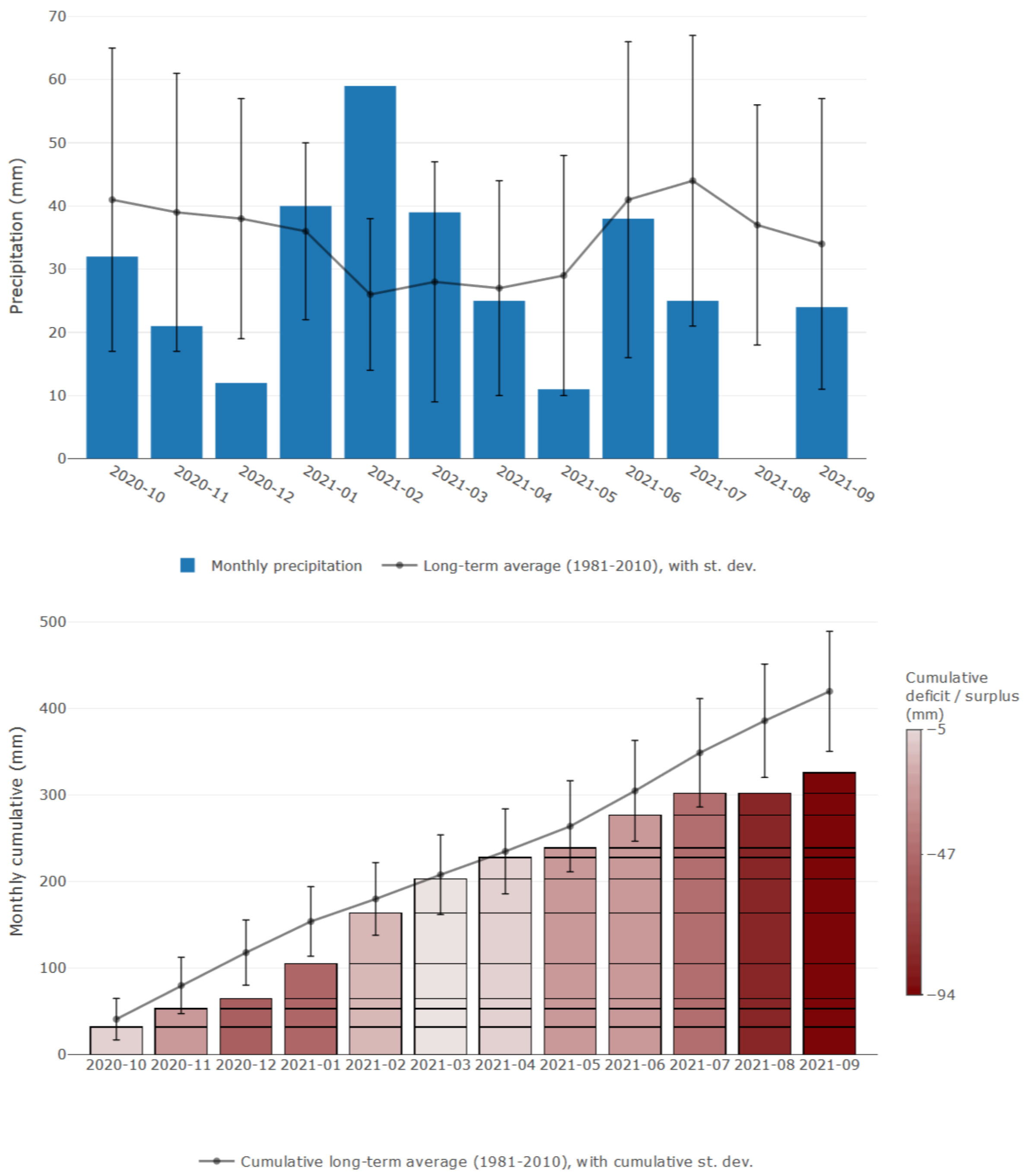

Figure 6: *Monthly total (upper) and cumulative (lower) precipitation - evolution over time for Orenburg Oblast (Russia) (52.4N, 54.6E) from October 2020 to September 2021*

Standardized Precipitation Index (SPI)

The GDO indicator SPI[3], as one of the driving components of the RDrI-Agri, provides information concerning the intensity and duration of the precipitation deficit (or surplus). Analysing data for different accumulation periods (Figure 7) the current dry conditions can be attributed to a yearly mean precipitation below the long-term average. SPI-6 shows the wider extent and the highest amplitude of the deficit.

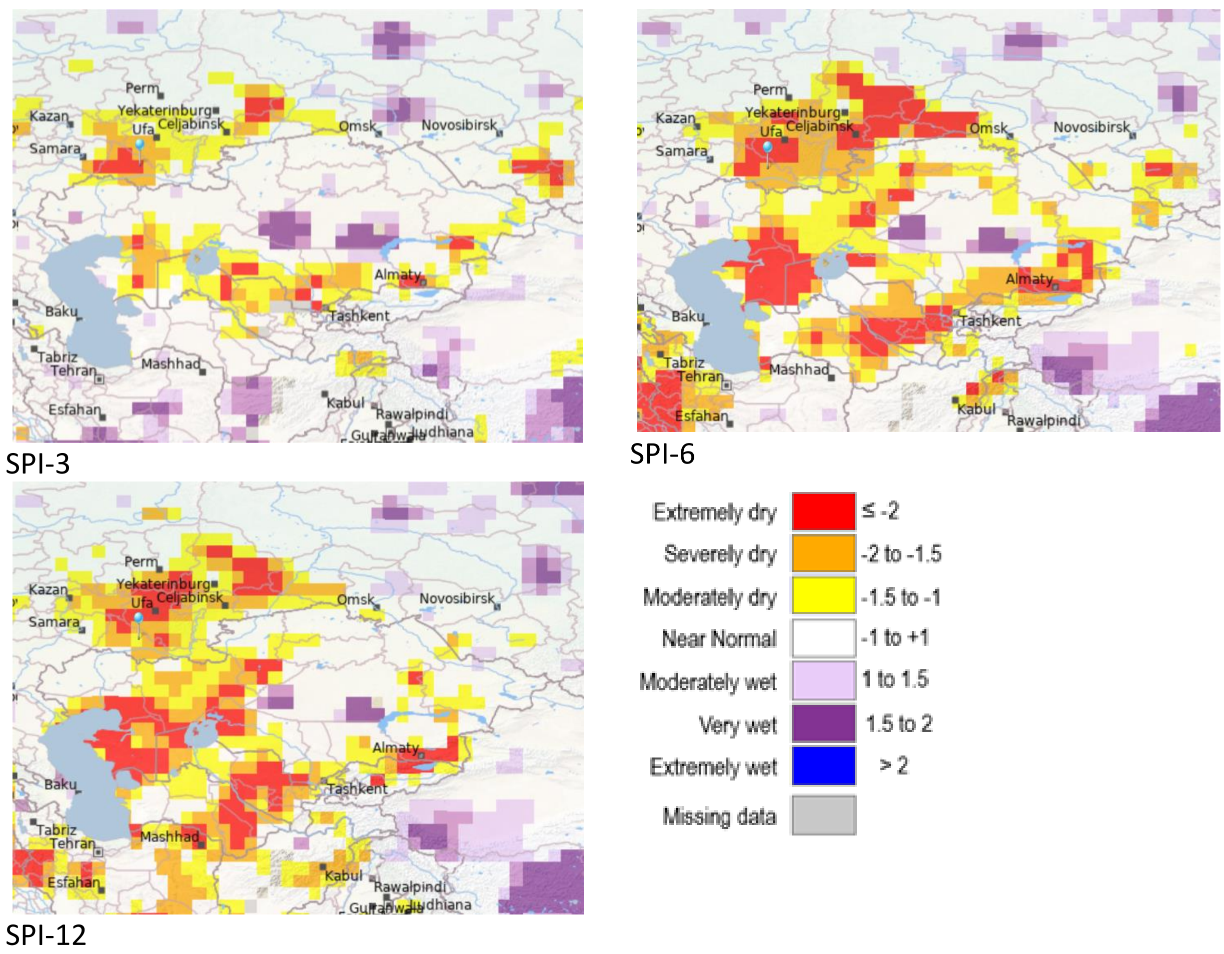

Figure 7: *Standardized Precipitation Index (SPI-3; SPI-6; SPI-12) September 2021*

[3] SPI is used to monitor the occurrence of drought. The lower (i.e. more negative) the SPI, the more intense is the drought. SPI can be computed for different accumulation periods: the 3 months period is often used to evaluate agricultural drought and the 12 month accumulation period can be used for hydrological drought, when rivers fall dry and groundwater tables lower.

SPI-3 computed for each month features in May already a relevant precipitation deficit mainly in southern Urals and in June the persistence of lack of precipitation drove to a significant wider extent of the affected areas towards the southern regions. Then in July just a temporary partial improvement happened in the southern Urals with an immediate worsening already in August (Figure 8).

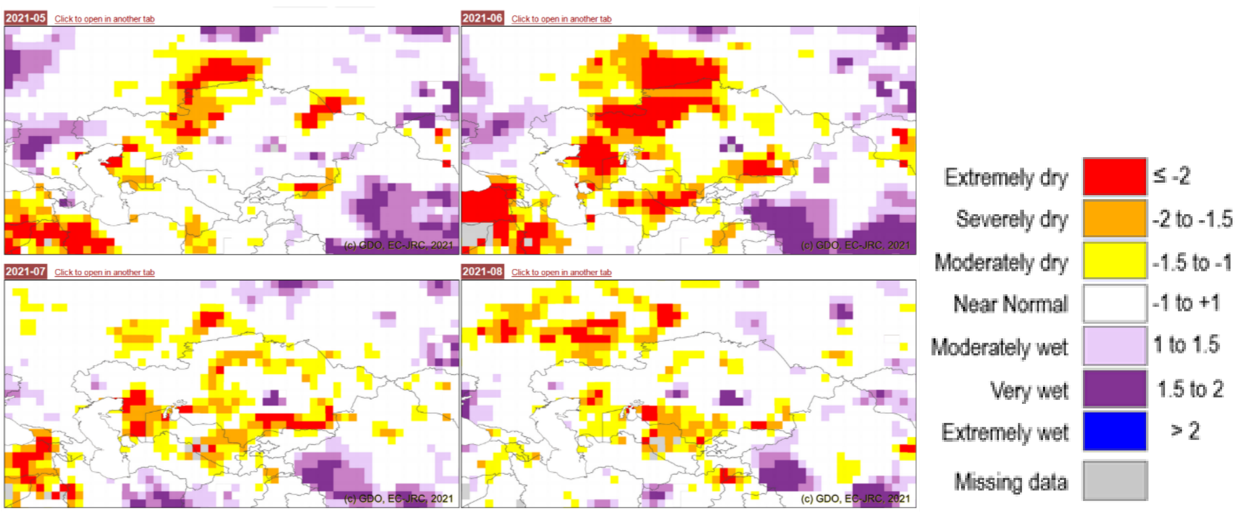

Figure 8: *Standardized Precipitation Index (SPI-3) monthly maps from May 2021 to August 2021*

The SPI evolution over the last year in the selected regions defines quite well the origin and the timing of the extensive present drought

In Kazakhstan (Figure 9), a slightly wetter than normal spring has been followed by a very dry summer and this explains the extremely low value of SPI-6 for September. In southern Urals (Figure 10) the magnitude of deficit appears to be smaller, and the evolution is smoother, with a significant time delay respect to Kazakhstan.

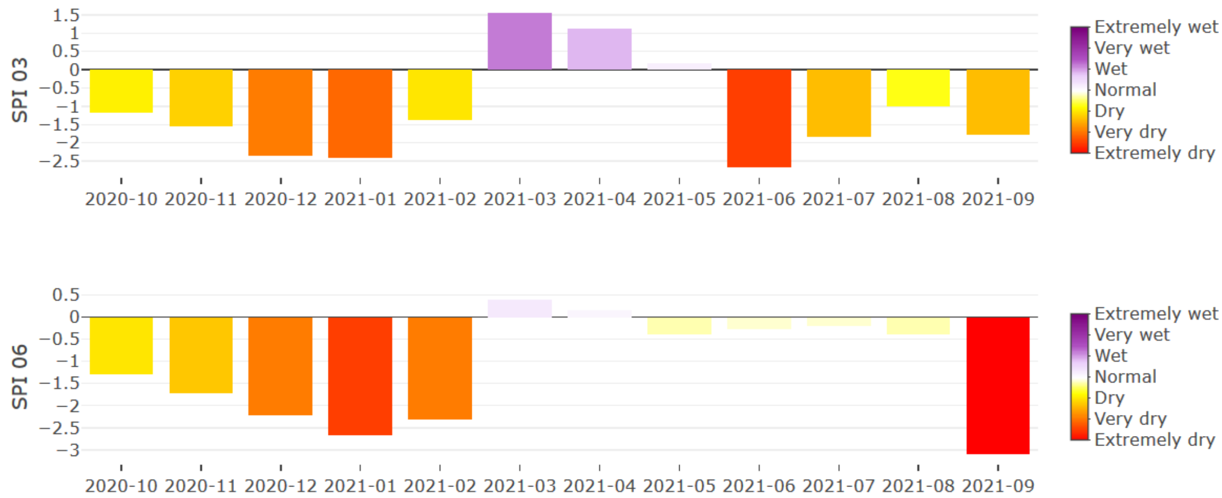

Figure 9: *Standardized Precipitation Index (SPI-3, SPI-6) evolution over time for Mangystau Region (Kazakhstan) from October 2020 to September 2021*

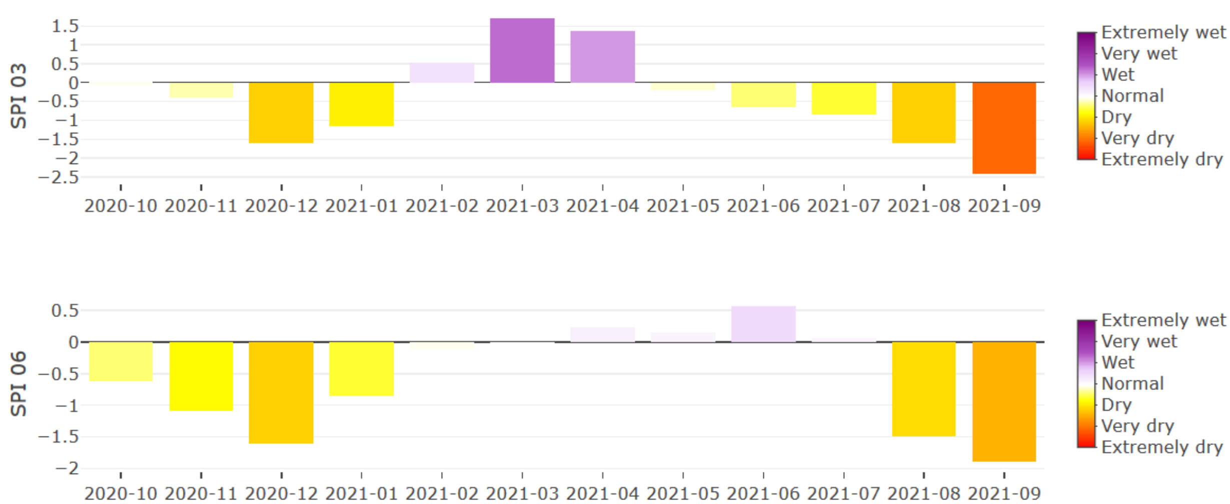

Figure 10: *Standardized Precipitation Index (SPI-3, 6, 12) evolution over time for Orenburg Oblast (Russia) from October 2020 to September 2021*

Indicator for forecasting unusually wet and dry conditions

According to the modeled indicator for forecasting unusually wet and dry conditions from October to December 2021 (see Figure 11), no warning of unusually dry conditions is found in Turan Depression and only small areas of southern Urals appear in low warning. This may not significantly improve the drought situation but at least should be enough to not get worse.

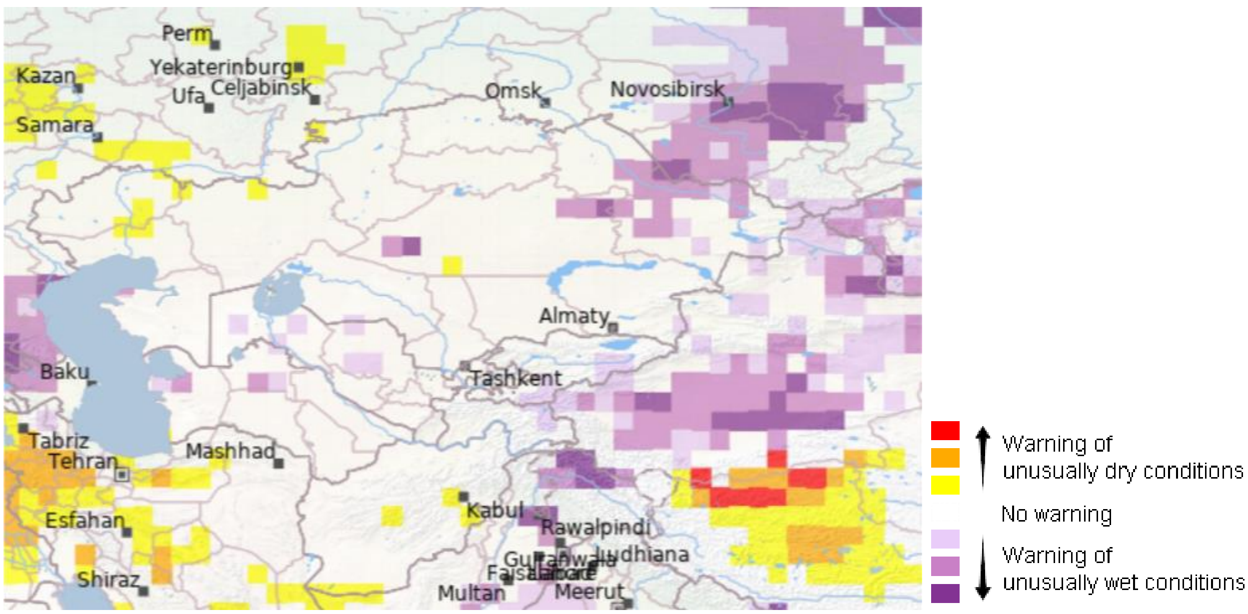

Figure 11: *Indicator for forecasting unusually wet and dry conditions for 3 months, October to December 2021.*

Soil moisture and groundwater anomalies

Because of the prolonged lack of precipitation, the main effect is the reduction of the water content in the soil. The aim of the GDO soil moisture anomaly indicator is to provide an assessment of the topsoil water content, which is a direct measure of drought conditions, specifically regarding the difficulty for plants to extract water from the soil.

At the first ten-day period of October 2021 drier conditions (Figure 12) are observed approximately in the regions of southern Urals, where the drought event started later. In the other regions generally normal or slightly wetter than normal conditions are observed, confirming a reduction of the severity of the drought event in the latter weeks.

Checking the time evolution of the soil moisture anomaly maps, a significantly drier than normal June 2020 is confirmed (Figure 13), and later on a slow and still incomplete recovery process is visible.

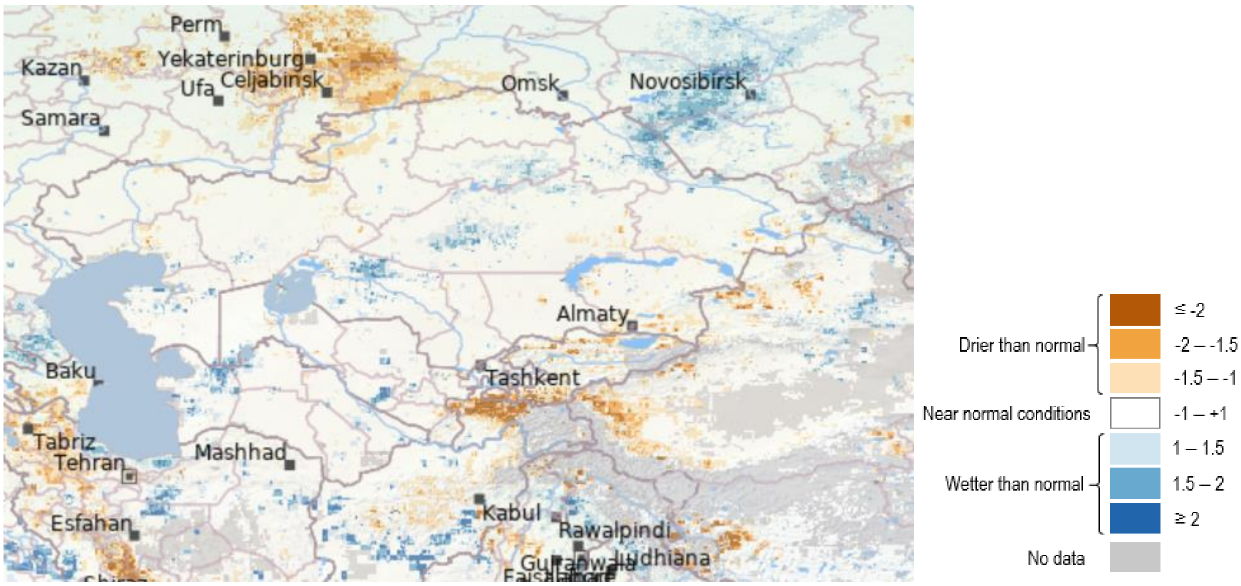

Figure 12: *Soil Moisture Anomaly - 1st ten-day period of October 2021*

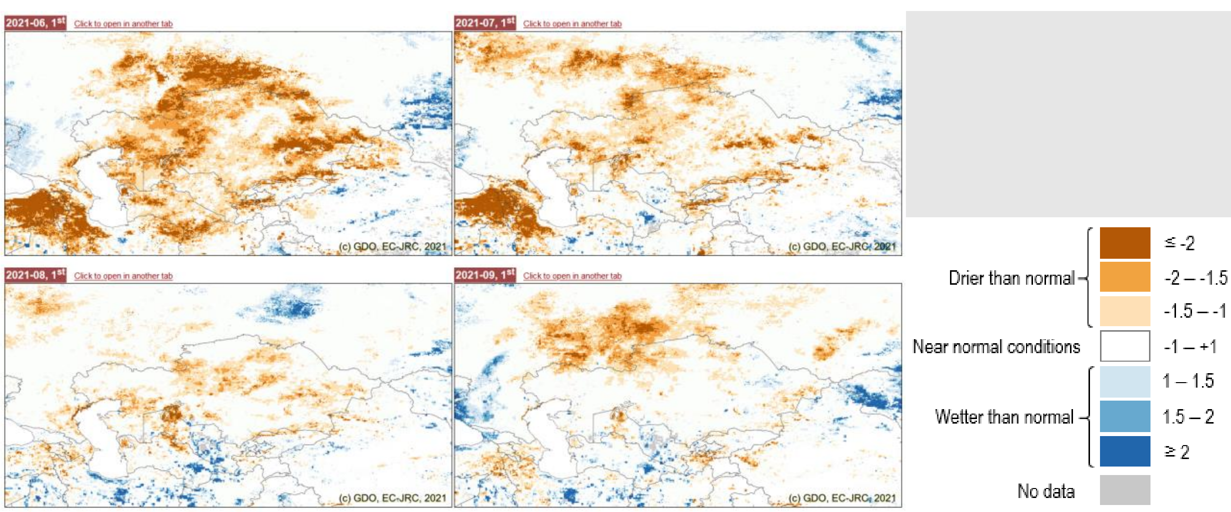

Figure 13: *Soil Moisture Anomaly - 1st ten-day period of each month from June 2021 to September 2021*

Looking more in detail at the selected areas in Figure 14, an abrupt rise of areas under drier than normal soil conditions in Kazakhstan started from May 2021. In southern Urals dry conditions appear to be more prolonged, starting in June 2021, fluctuating with a partial recovery in August but still ongoing at time of writing (Figure 15).

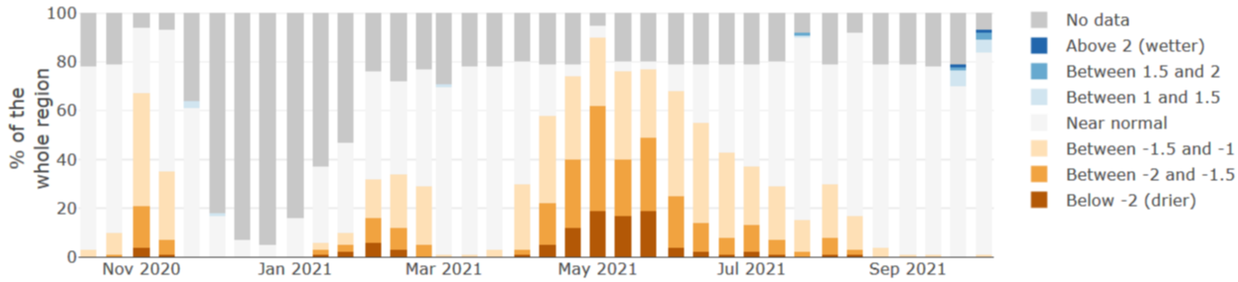

Figure 14: *Soil moisture anomaly evolution over time for Mangystau Region (Kazakhstan) from the last ten days of October 2020 to the first ten days of October 2021*

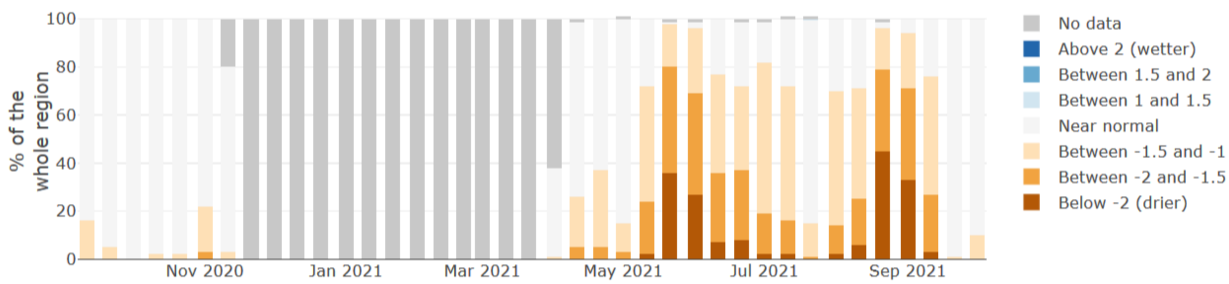

Figure 15: *Soil moisture anomaly evolution over time for Orenburg Oblast (Russia), from the last ten days of October 2020 to the first ten days of October 2021*

The Total Water Storage (TWS) Anomaly indicator is used for determining the occurrence of long-term hydrological drought conditions and it is often used as a proxy of groundwater drought. It is computed as anomalies of GRACE-derived TWS data.[4] TWS features good correlation with long-term SPI (12, 24 and 48 months).[5]

The TWS anomaly represents a reliable indicator in terms of groundwater availability anomaly and hence is a proxy for detecting anomalies in river flow levels. In August 2021 (Figure 16) a very

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[4] Landerer, F.W.; Swenson, S.C. Accuracy of scaled GRACE terrestrial water storage estimates. Water Resour.Res. 2012, 48, W04531

[5] Cammalleri, C., Barbosa, P., Vogt, J.V. 2019. Analysing the Relationship between Multiple-Timescale SPI and GRACE Terrestrial Water Storage in the Framework of Drought Monitoring. Water 11(8), 1672. https://doi.org/10.3390/w11081672.

wide area ranging from Urals and extending almost to the whole plains of the Turan Depression was suffering from severe negative anomalies.

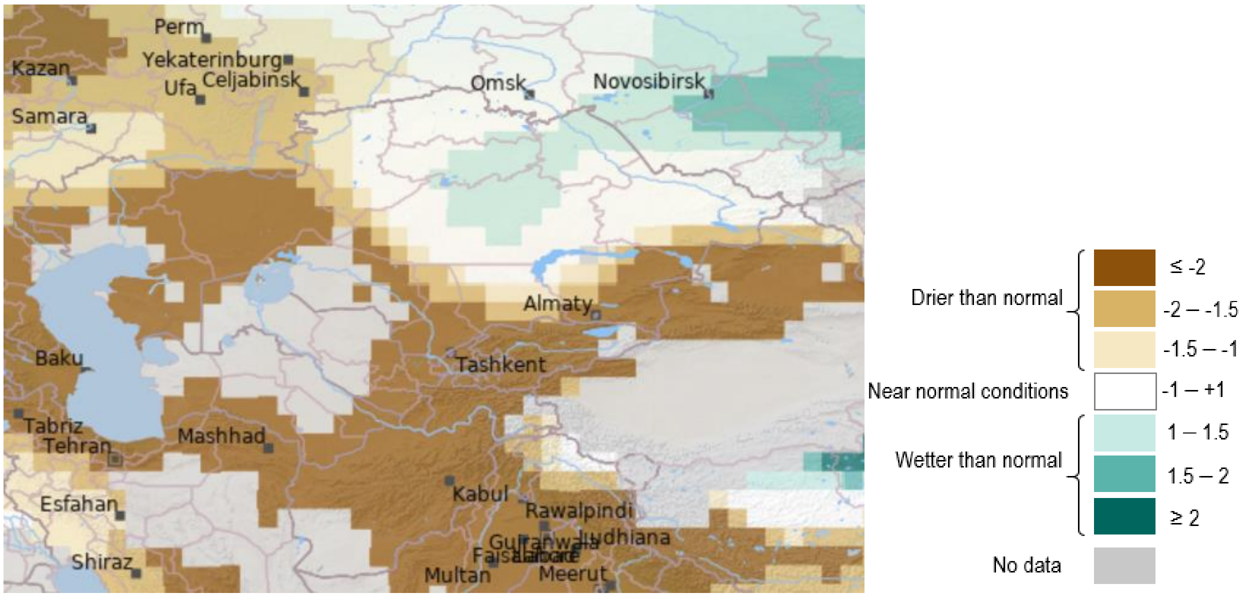

Figure 16: *Gravity Recovery and Climate Experiment (GRACE) Total Water Storage (TWS) Anomaly, August 2021*

fAPAR anomaly

The satellite based GDO indicator fraction of Absorbed Photosynthetically Active Radiation (fAPAR) represents the fraction of the solar energy absorbed by leaves. fAPAR anomalies, specifically the negative deviations from the long-term average over the same period, are a good indicator of drought impact on vegetation.

In accordance with the other indicators, an impact on vegetation photosynthetic activity is mainly detected in the southern Urals and over the Kazakhstan plains (Figure 17). Impacts on vegetation and soil moisture/groundwater are not always in phase and coherent due to delays in vegetation development and, in general, different timing of the two processes. In agreement with the previous analysis, the severest impacts on vegetation were visible mainly in June and July 2021. Afterwards, conditions remained stable and the recovering phase has not started yet (Figure 18).

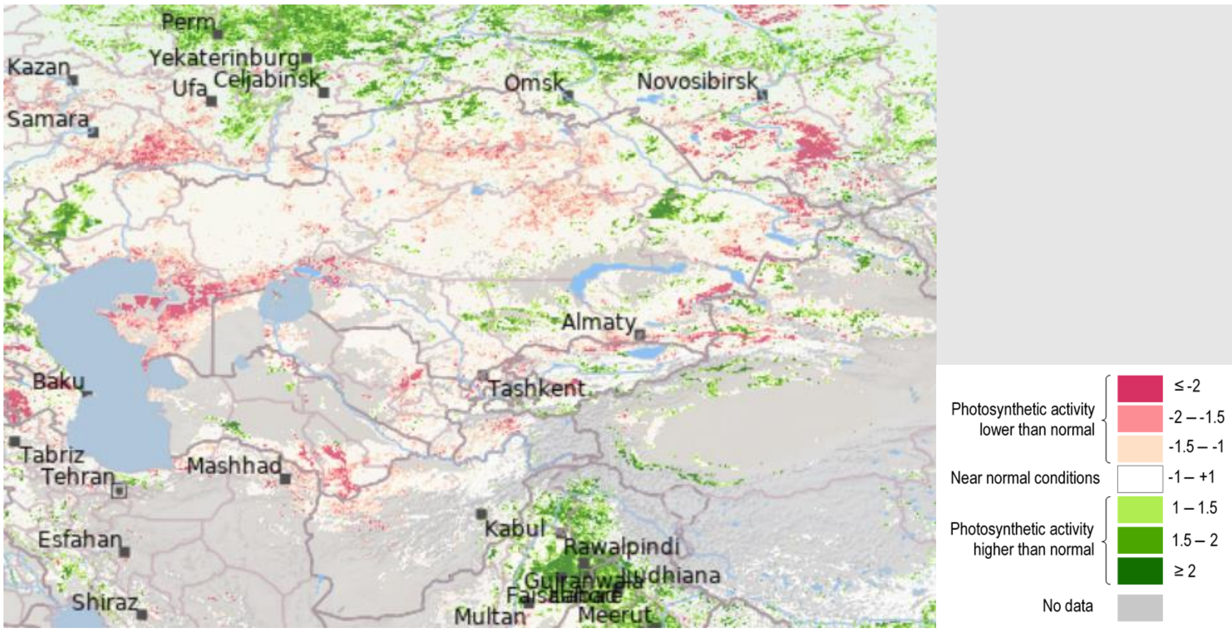

Figure 17: *fAPAR Anomaly - 1st ten-day period of October 2021*

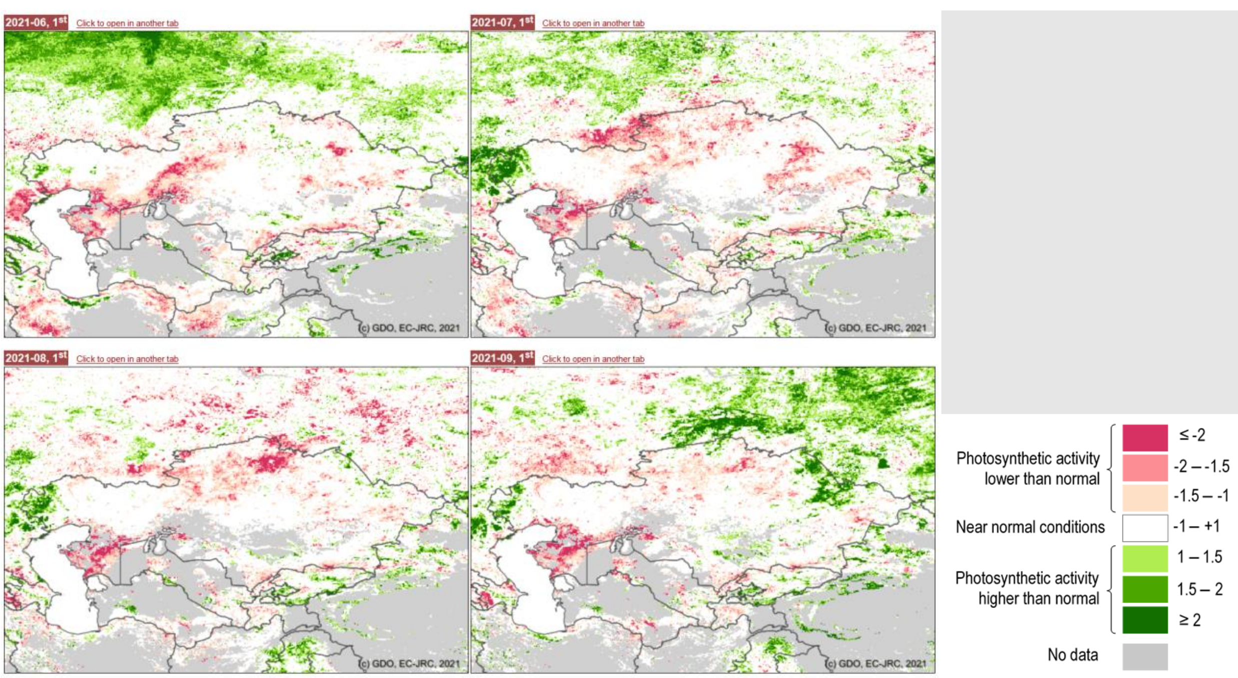

Figure 18: *fAPAR Anomaly - 1st ten-day period of each month from June 2021 to September 2021*

Time evolution of the vegetation conditions in the two selected regions confirms the previous analysis, showing a progressively increasing impact in Kazakhstan starting in April 2021, and in southern Urals starting in June 2021 with both a shorter temporal span and minor percentages of affected areas (Figure 19 and Figure 20).

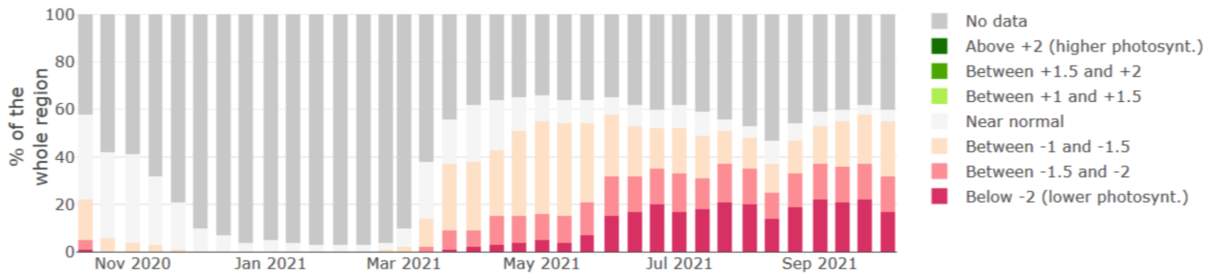

Figure 19: *fAPAR evolution over time for Mangystau Region (Kazakhstan) from the last ten days of October 2020 to the first ten days of October 2021*

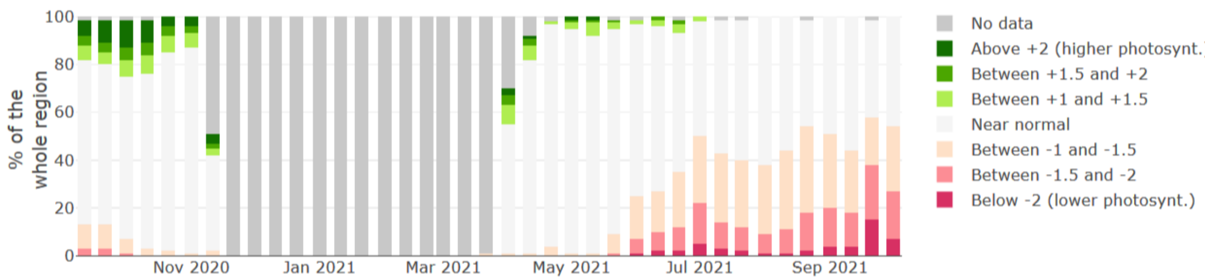

Figure 20: *fAPAR evolution over time for Orenburg Oblast (Russia), from the last ten days of October 2020 to the first ten days of October 2021*

Temperature anomaly[6]

The regions of southern part of Urals mountain range and Turan Depression have been widely affected by heatwaves and high temperatures in late spring and summer 2021. Temperature is a major driver for drought, together with precipitation deficit. In addition, temperature, together with wind, is the main driver of evapotranspiration, which is the loss of water from soil and vegetation through air. A severe and widespread heatwave occurred during the period from May to August 2021 (Figure 21).

[6] Source: JRC's Monitoring of Agricultural Resources (MARS) – Anomaly Hotspots of Agricultural Production (ASAP) service https://mars.jrc.ec.europa.eu/asap/index.php

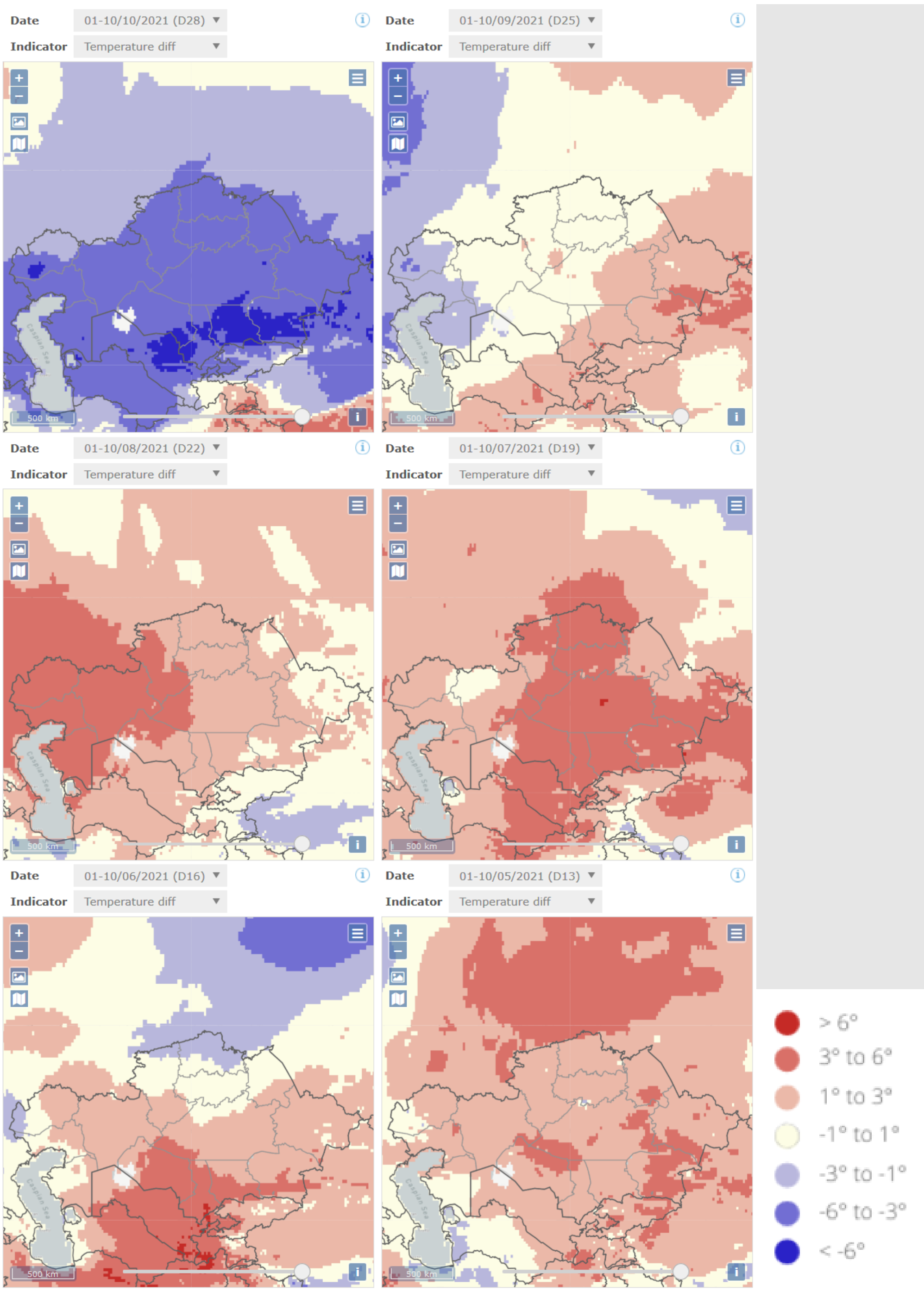

Figure 21: *Temperature Anomaly for the first 10-day period of the last six months (backward from the 1st ten-day period of October 2021 to the 1st ten-day period of May 2021). Source: JRC's Monitoring of Agricultural Resources (MARS) – Anomaly Hotspots of Agricultural Production (ASAP)*

Fire Danger Forecast[7]

The wildfire hazard is a direct consequence of elevated temperature anomalies and surface dryness, in combination with the availability of fuel (dry litter and wood).

The Global Wildfire Information System (GWIS) provides mapping services of the fire danger forecast all over the world. The comparison between the end of June forecast and the end of October forecast shows an extreme severe condition in summer that has not recovered at the beginning of autumn 2021 yet.

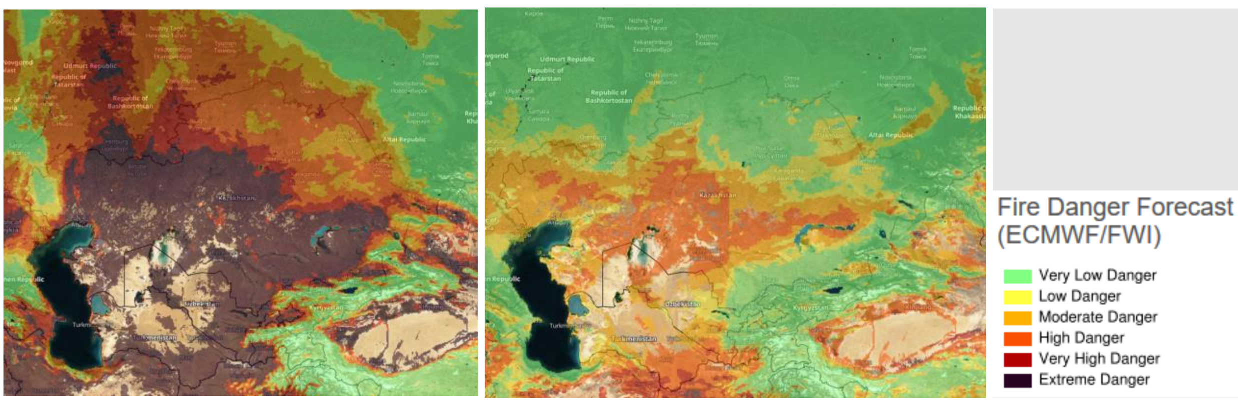

Figure 22: *Fire danger forecast expressed by the Fire Weather Index for 30th of June 2021 issued on the same day (left) and for 30th of October 2021 issued on 25th of the same month (right). Source: Global Wildfire Information System, GWIS*

Reported impacts

In October 2021 impacts of drought were reported in many administrative units of the Russian Federation.
The Ministry of Agriculture and Food Resources of the Nizhny Novgorod Oblast (Russian Volga Federal District) estimated at about 151 million Rubles (around 1.87 million €[8]) the losses due to livestock deaths or damages to agricultural crops[9], following a strong anomaly of temperature

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[7] Source: JRC Global Wildfire Information System - https://gwis.jrc.ec.europa.eu/apps/gwis_current_situation/

[8] Rate used for this and the next conversions is 1 RUB = 0,0123915 EUR, issued on 26th October 2021 at 14:35 UTC

[9] https://tass.ru/ekonomika/12702763 (in Russian)

(7-12 °C more than the climate norm), dry winds, lack of rain and consequent soil moisture negative anomaly during the growing period. Despite the existing grain storage capacity still meet the needs of the region, a compensation for affected farmers to the central government was taken into consideration, following the declaration of a regional emergency due to drought, issued at the end of September 2021.

An emergency regime was in place also in the Sverdlovsk Oblast from 22nd July to 18th October, with estimated losses of 4 billion Rubles (around 49.56 million €)[10], and in the Kurgan Oblast (one of the most important agricultural regions in the Urals, mainly for grain crops, vegetables, and potatoes) from 27th July to the end of August, with estimated loss of 5.6 billion Rubles (around 69.42 million €), as reported to the Ministry of Agriculture of the Russian Federation[11].

Rise of prices was registered in the area, for example for oat: drought and consequent reduced acreage and low yields contributed to worsen a situation already difficult due to an increase in the cost of raw materials and packaging[12]. Vegetables and meat increase in price was observed also in the Sverdlovsk Oblast and was considered a consequence of drought by the Ural Main Directorate of the Bank of Russia[13]. The annual food inflation in September climbed to 7.1% because of a combination of factors: yields decrease in open-field crops due to summer drought and heat, costs increase for heating greenhouses to face cold weather in September, growth of transportation costs and extra-costs to face lack of fodder crops for livestock.

According to its State Council, the Republic of Tatarstan appears less impacted because it has a good coping capacity, but the consequences of the 2021 drought are expected to last for another two years[14].

After the strong heatwave of June and July (mainly in southern and western regions of Kyzylorda, Mangystau and Turkestan, with a record temperature of 46.5°C in an area with a baseline average of 28.3°C)[15] , an abnormally warm and dry growing season, numerous dust storms, and dramatic

[10] https://www.justmedia.ru/news/society/v-sverdlovskoy-oblasti-snyali-rezhim-chs-izza-zasukhi (in Russian)

[11] https://tass.ru/ekonomika/12655811 (in Russian)

[12] https://www.rbc.ru/business/18/10/2021/616842579a794719793cad10 (in Russian)

[13] https://www.uralinform.ru/news/society/345278-ekonomisty-obyasnili-podorojanie-myasa-i-ovoshei-v-sverdlovskoi-oblasti/ (in Russian)

[14] https://www.tatar-inform.ru/news/marat-axmetov-tatarstanskoe-selskoe-xozyaistvo-v-sostoyanii-perezit-udar-zasuxi-5839602 (in Russian)

[15] https://reliefweb.int/disaster/dr-2021-000085-kaz

impacts especially for livestock[16,17], Kazakhstan encountered lower-than-average yields but above-average grain quality in most regions[18].

[16] https://www.dw.com/en/animals-die-of-starvation-in-kazakhstan-drought/av-58791109

[17] https://www.washingtonpost.com/world/2021/08/09/horses-kazakhstan-heatwave-grave/

[18] https://www.graincentral.com/markets/drought-russian-export-tax-cloud-kazakh-trade-flows/

GDO indicators versions:

The GDO indicators appear in this report with the following versions:

- Ensemble Soil Moisture Anomaly 2.3.0
- fAPAR (fraction of Absorbed Photosynthetically Active Radiation) Anomaly 1.3.1
- Gravity Recovery and Climate Experiment (GRACE) Total Water Storage (TWS) Anomaly 1.1.0
- Indicator for forecasting unusually wet and dry conditions 1.0.0
- Precipitation (GPCC) 1.2.0
- Risk of Drought Impact for Agriculture (RDrI-Agri) 2.3.2
- Standardized Precipitation Index (SPI, GPCC) 1.2.0

Check https://edo.jrc.ec.europa.eu/download for more details on indicator versions.

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