European Commission

Drought in Europe
July 2022

GDO Analytical Report

2022

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Joint Research Centre

GDO Analytical Report

Drought in Europe - July 2022

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 13/07/2022

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Executive summary

- The severe drought affecting several regions of Europe since the beginning of the year continues expanding and worsening. Dry conditions are related to a wide and persistent lack of precipitation combined with early heatwaves in May and June.
- The severe precipitation deficit has impacted river discharges widely across Europe.
- Reduced stored water volume has had severe impacts on the energy sector for both hydropower generation and cooling systems of other power plants.
- Competition for water resources is high and started earlier than usual. Water and heat stresses have reduced crop yield and crop yield potential. Water supply may be compromised in the coming months.
- Drier than normal conditions are forecasted for the next three months in large areas of Europe.

Combined Drought Indicator (CDI)

A staggering portion of Europe is currently exposed to warning and alert drought levels, associated with either soil moisture deficit or its combination with vegetation stress (Fig. 1). Compared to the previous months drought hazard has been increasing, especially in: France, Romania and neighbouring regions, western Germany, and several Mediterranean regions (central and southern Italy, southern Greece, Croatia, Bosnia Herzegovina and the Iberian Peninsula). Local recovery is observed in limited areas of France and the eastern Mediterranean. Regions already affected by drought in spring (e.g. northern Italy, south-eastern France, some areas in Hungary and Romania), are still under similar or worse conditions.

Drought in Europe - July 2022

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 13/07/2022

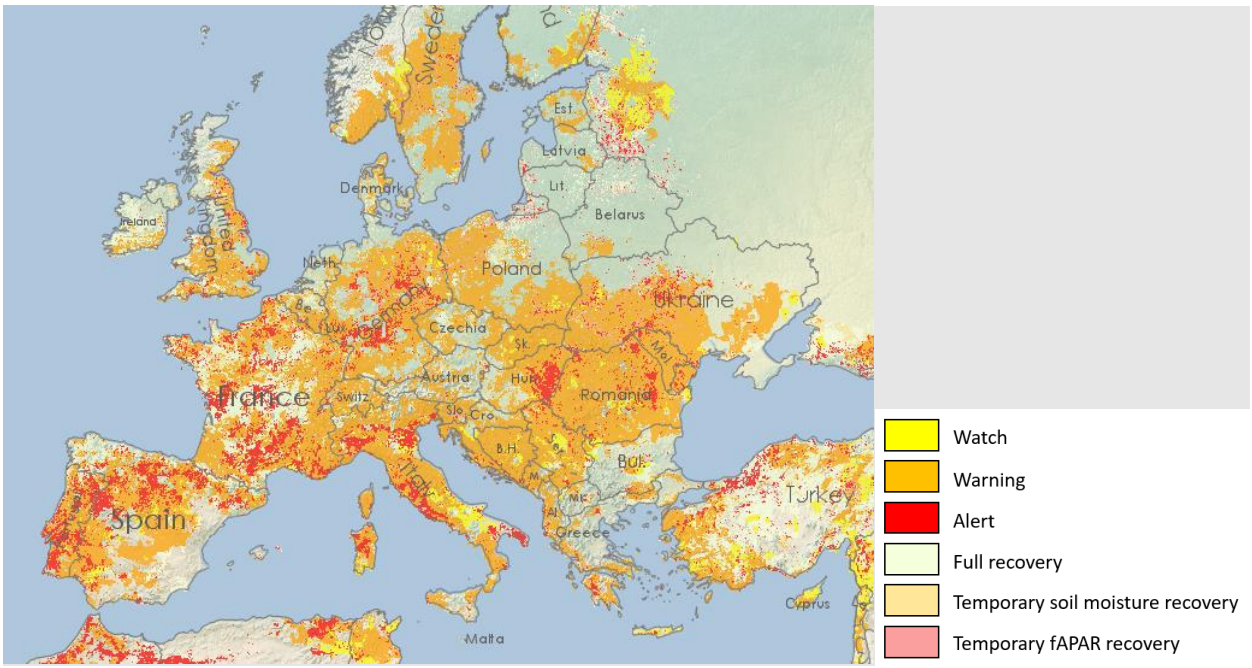

Figure 1: Combined Drought Indicator (CDI v.2.1) – end of June 2022.

Large-scale atmospheric conditions

Late spring and early summer 2022 have been characterised by anomalous anticyclonic conditions over most of western and central Europe (Fig. 2). An anomalous cyclonic pattern has been observed over north-eastern Europe (Fig. 2). Both the anomalous high and low pressures anomalies in Europe appear to be part of a circumglobal pattern that may have simultaneously affected other regions in Asia and North America. Anomalies across Europe (and elsewhere) for both near surface temperature and total precipitation are well explained by the anomalies in atmospheric circulation. Therefore, being driven by these large-scale atmospheric conditions, the 2022 spring and summer concurrent European drought and heatwaves may reinforce each other.

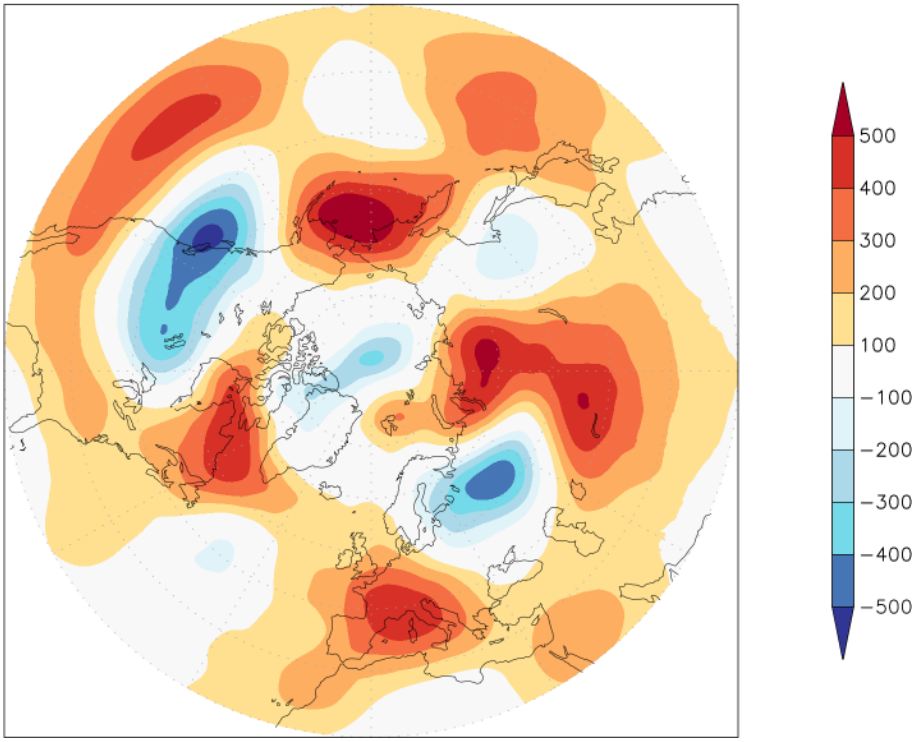

Figure 2: April - June 2022 large-scale atmospheric conditions: mean anomalies of geopotential height at 500 hPa (gpm) from the ECMWF ERA5 reanalysis. The reference climatology is 1980-2019. Source: Climate explorer (https://climexp.knmi.nl)

Standardized Precipitation Index (SPI)

The regions most affected by negative precipitation anomalies in the second quarter of 2022 are: central Italy; a wide area across Poland, Ukraine, Slovakia Hungary, Romania and Moldova; the eastern Mediterranean (SPI-3, Fig. 3).

Extending the analysis on the precipitation deficit to the first half of 2022, a severe-to-extreme broad meteorological drought emerges in: Italy, south-western France, eastern Europe, and large part of the Balkans (SPI-6, Fig. 4). The yearly accumulated deficit (SPI-12, not shown) resembles quite closely the one identified by the SPI-6.

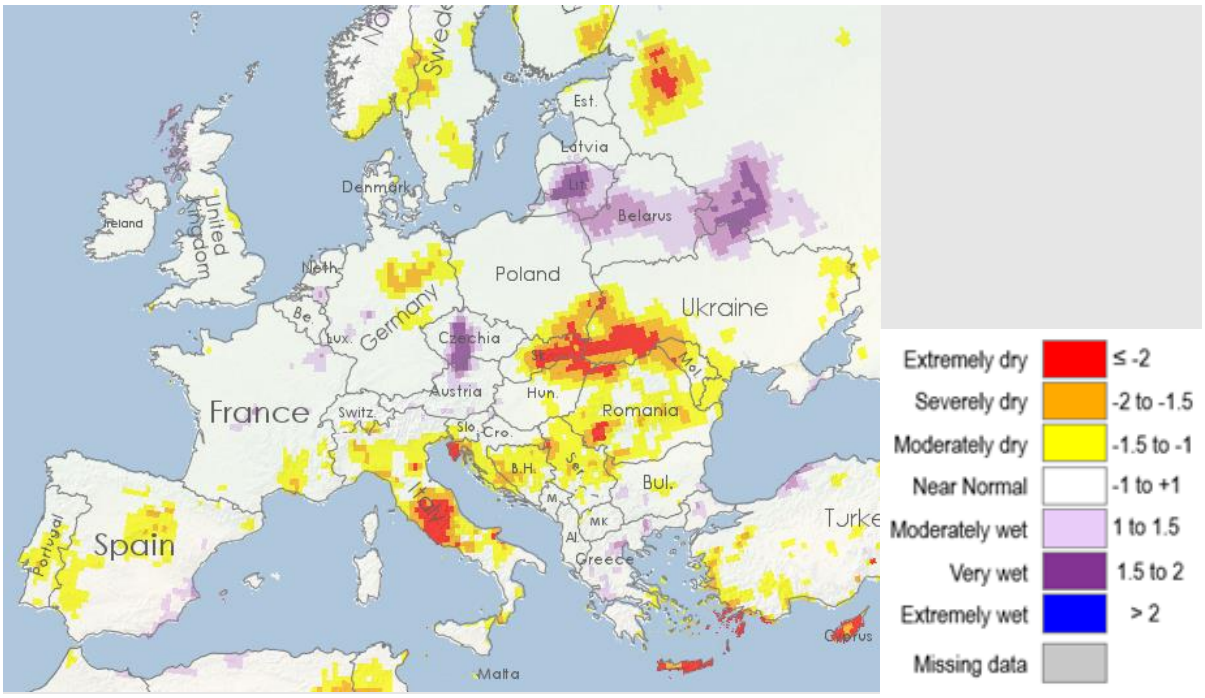

Figure 3: *Standardized Precipitation Index SPI-3, April-June 2022.*

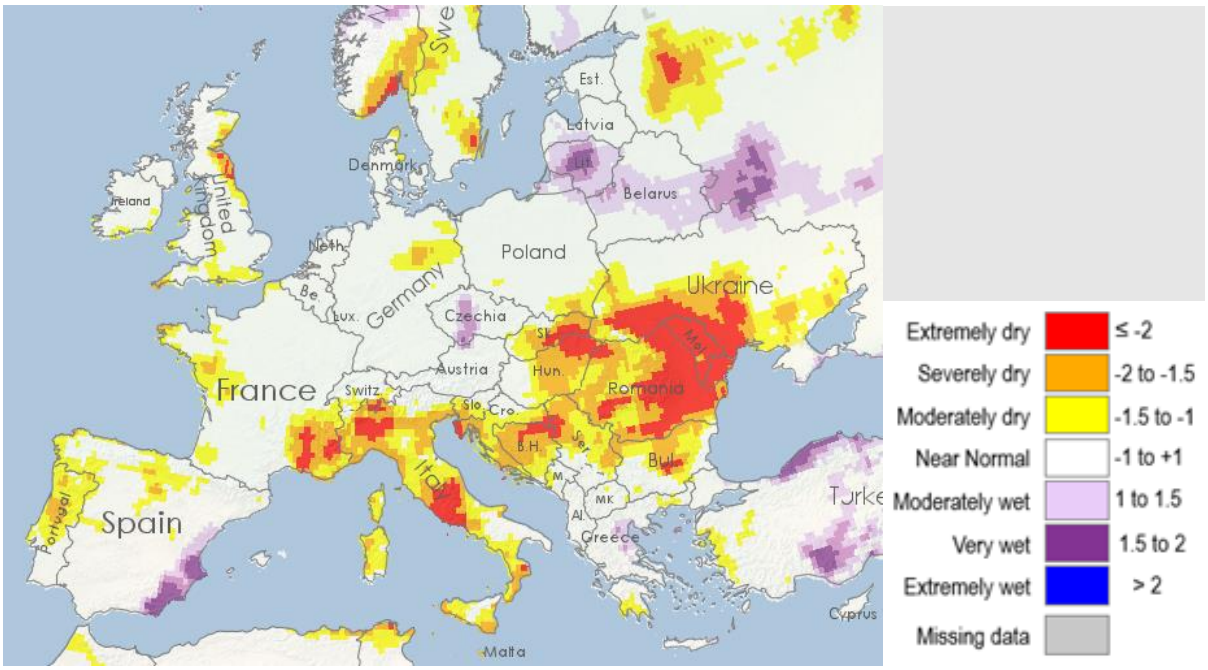

Figure 4: *Standardized Precipitation Index SPI-6, January-June 2022.*

Soil Moisture Anomaly

Soil moisture anomalies remain markedly negative in most of Europe (Fig. 5). Compared to May 2022 and early June, overall, no improvements are detected, and changes are primarily variations within the negative anomaly side. The only significant exception is central and northern France; elsewhere anomalies may have lessened, but have not disappear. On the contrary, soil moisture anomalies have worsened in a wide region spanning from eastern Hungary and Slovakia to western Ukraine and Romania. Similarly, Germany and western Poland have experienced an extension and intensification of negative anomalies. The southern part of the Scandinavian Peninsula entered a condition of extreme moisture deficit. Portugal, Italy, and south-eastern France (already affected in the previous months to a varying degree) have not recovered, and negative soil moisture anomalies persist.

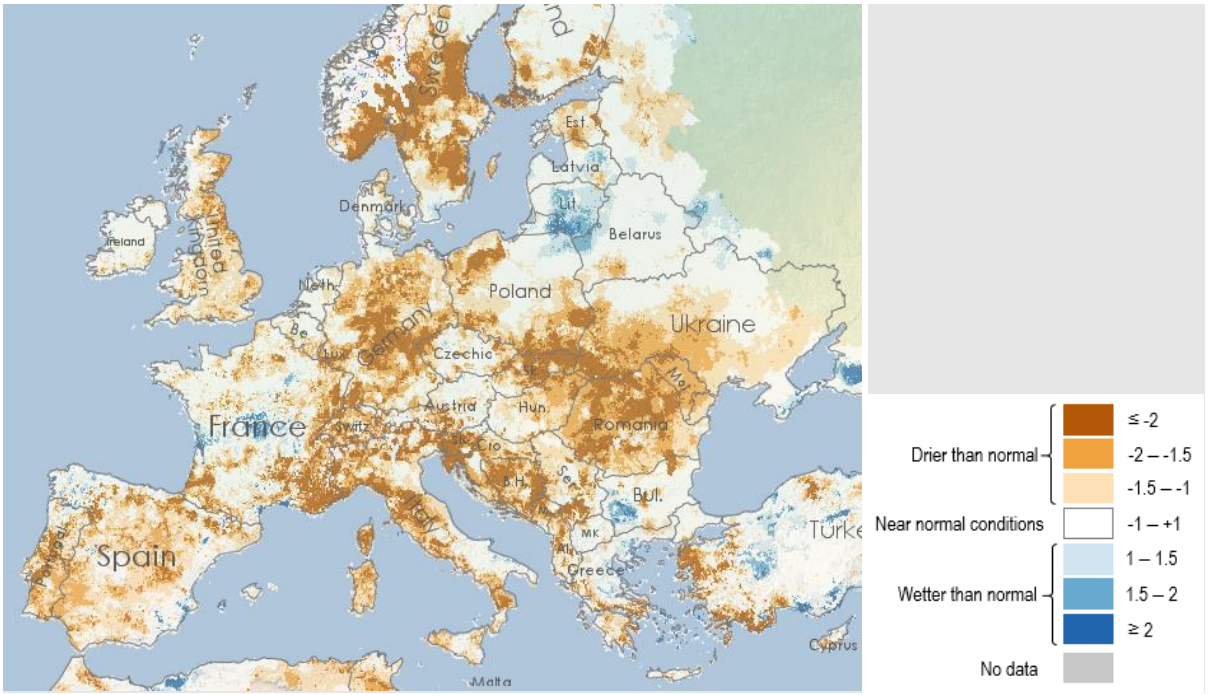

Figure 5: *Soil Moisture Anomaly - end of June 2022.*

FAPAR anomaly

According to Figure 6, western and central Europe are characterised by low-to-normal values of fAPAR, compared to the long-term average. Some areas show more pronounced negative anomalies, highlighting a widespread stress on vegetation: Italian lowlands; southern, central, and western France; central Germany; eastern Hungary; Portugal; northern Spain.

Along the Alps a pronounced positive anomaly is shown in Figure 6. This signal may be caused by an early start of the growing season and by an accelerated snow-melting due to early heatwaves.

Overall, comparing the current situation with the one at the end of May (when the earlier start of the growing season led to positive anomalies), June has shown a decrease in photosynthetic activity compared to the seasonal norm, with the exception of some regions along the Baltic Sea and further east to Ukraine.

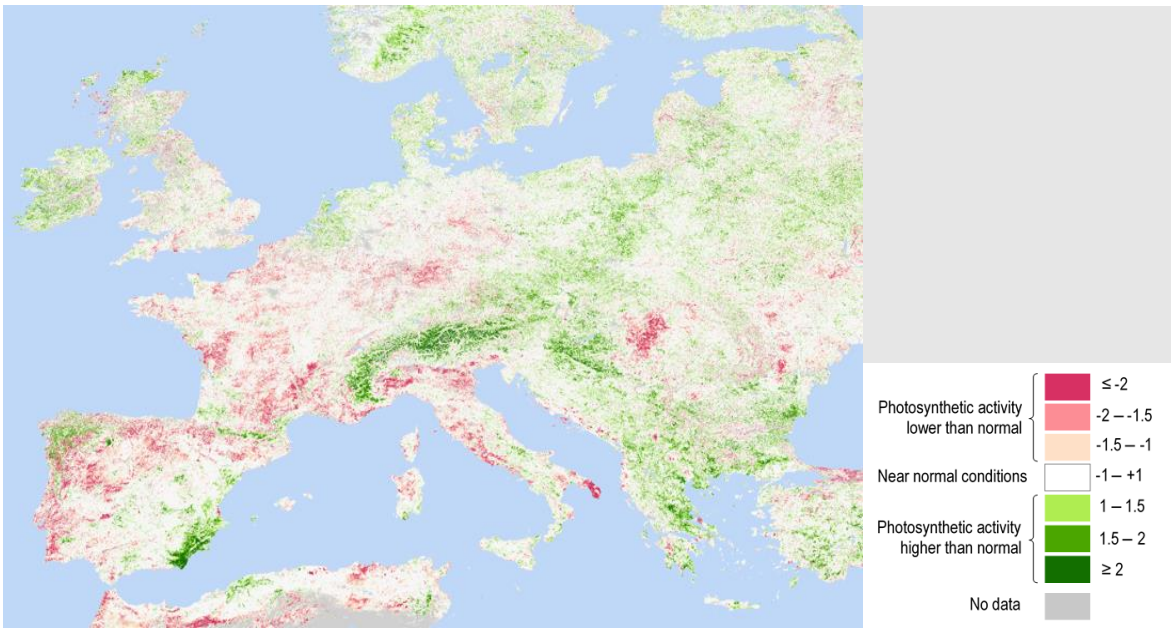

Figure 6: *fAPAR anomaly - end of June 2022.*

Low-Flow Index

At the end of June 2022, the Low-Flow Index (LFI; Fig. 7) shows lower values mainly in eastern Europe, northern Italy, and southern France. Recently, lower values have appeared also in Germany. However, rivers across other countries have also experienced low flows in some sections. As a notable exception, Danube levels are still in line with the average for the period, albeit decreasing in some regions[1].

[1] http://www.inhga.ro/diagnoza_si_prognoza_dunare; https://www.hidmet.gov.rs/eng/hidrologija/radio.php; https://www.noel.gv.at/wasserstand/#/en/Messstellen/Map/Durchfluss; https://www.hydroinfo.hu/en/hidinfo/hidinfo_graf_duna.html; https://www.doris.bmk.gv.at/en/fairway-information/water-levels/schwedenbruecke-donaukanal

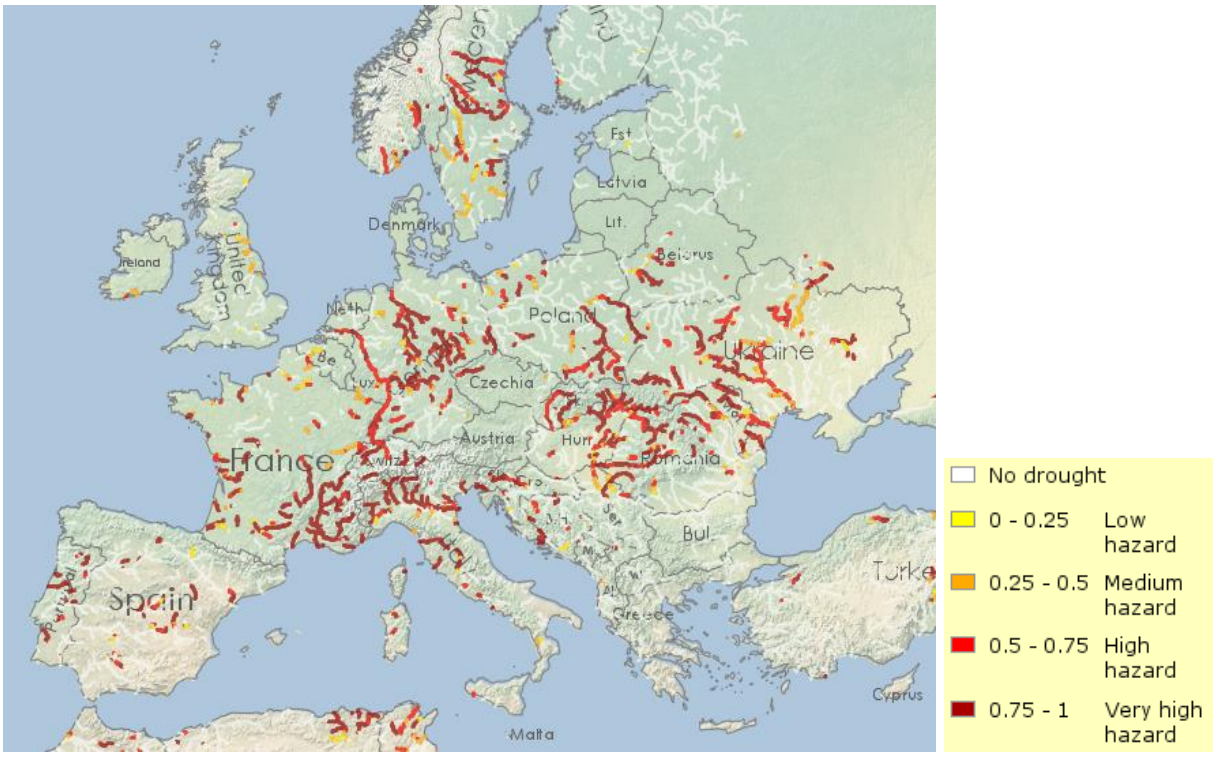

Figure 7: *Low-Flow Index (LFI) at the end of June 2022. A Low-Flow Index of 0 corresponds to no drought and a value of 1 to the highest drought hazard.*

Heatwaves

Hot temperatures increase evapotranspiration and trigger higher water demand, thus contribute substantially to enhance drought severity.

Western Europe experienced a prolonged first heatwave already in May 2022 (Fig. 8, top-left), dragging temperatures above the long-term average for the same month. In mid-June, another heatwave affected western Europe, from Spain to north-western Italy (Fig. 8, top-right). In Spain and France maximum daily temperatures above 40°C were recorded.

At the beginning of July, temperatures raised above normal in most of eastern and northern Europe. A long-lasting heatwave affected the southernmost regions of Italy too.

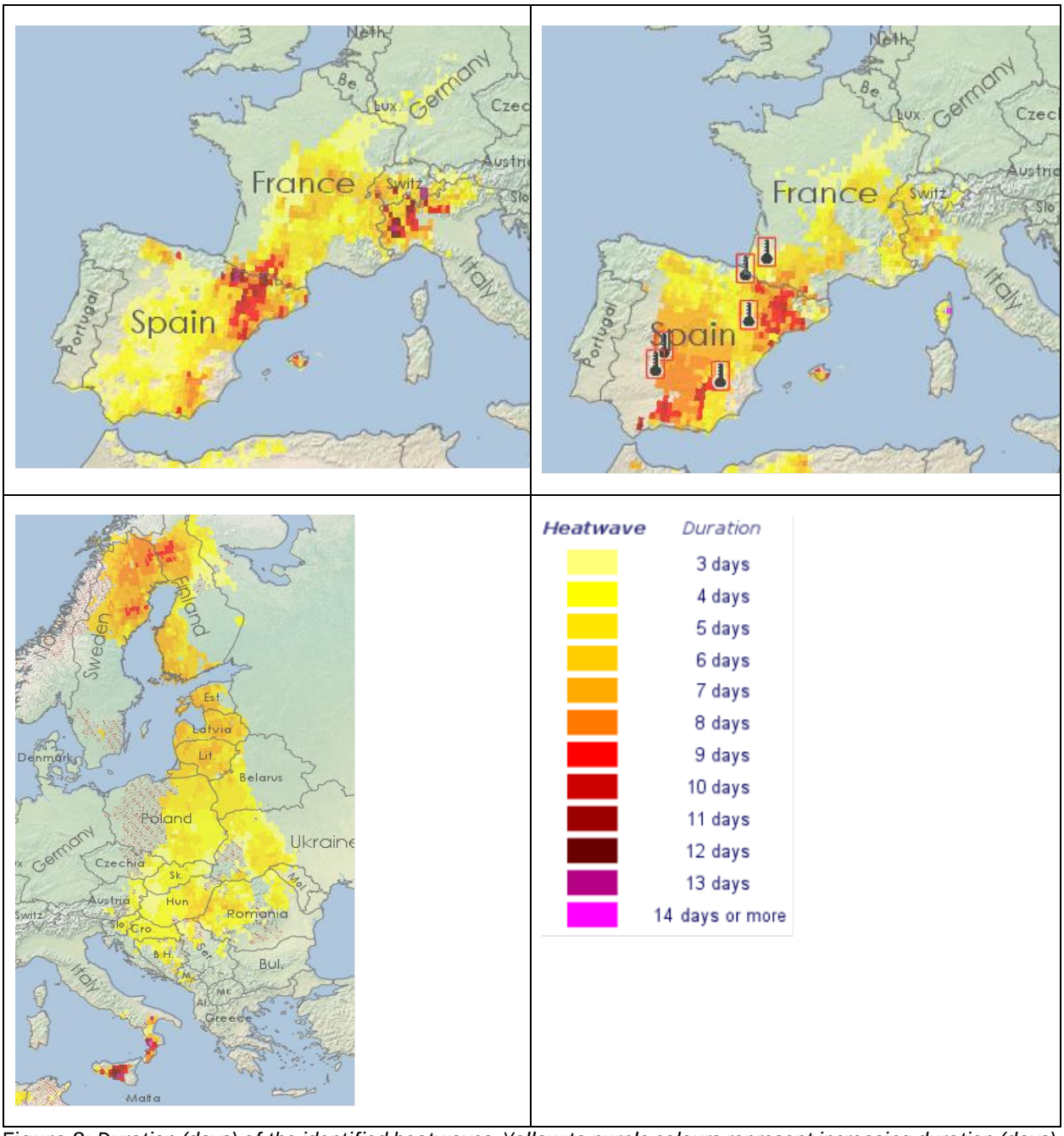

Figure 8: *Duration (days) of the identified heatwaves. Yellow to purple colours represent increasing duration (days), dashed lines show hot days (less than 3). Top-left panel: May 20th. Top-right panel: June 18th. Bottom-left panel: July 1st.*

Seasonal forecast

Severely drier than normal weather conditions are predicted over France, Germany, Switzerland, northern Spain and Portugal, northern Italy, Austria, Czechia, Slovakia, Hungary, northern Romania, Southern Poland and most of United Kingdom and Ireland in the period July-September 2022 (Fig. 9). These forecasts add concerns to the already very critical situation and, if confirmed, will exacerbate drought severity and the impacts on agriculture, energy and water supply. Seasonal forecasts from other modelling centres[2] confirm the anomalous temperature pattern, while some differences characterise the spatial pattern of precipitation. Some models, indeed, forecast drier-than-usual conditions shifted towards the Mediterranean region (with respect to the pattern shown in Fig. 9).

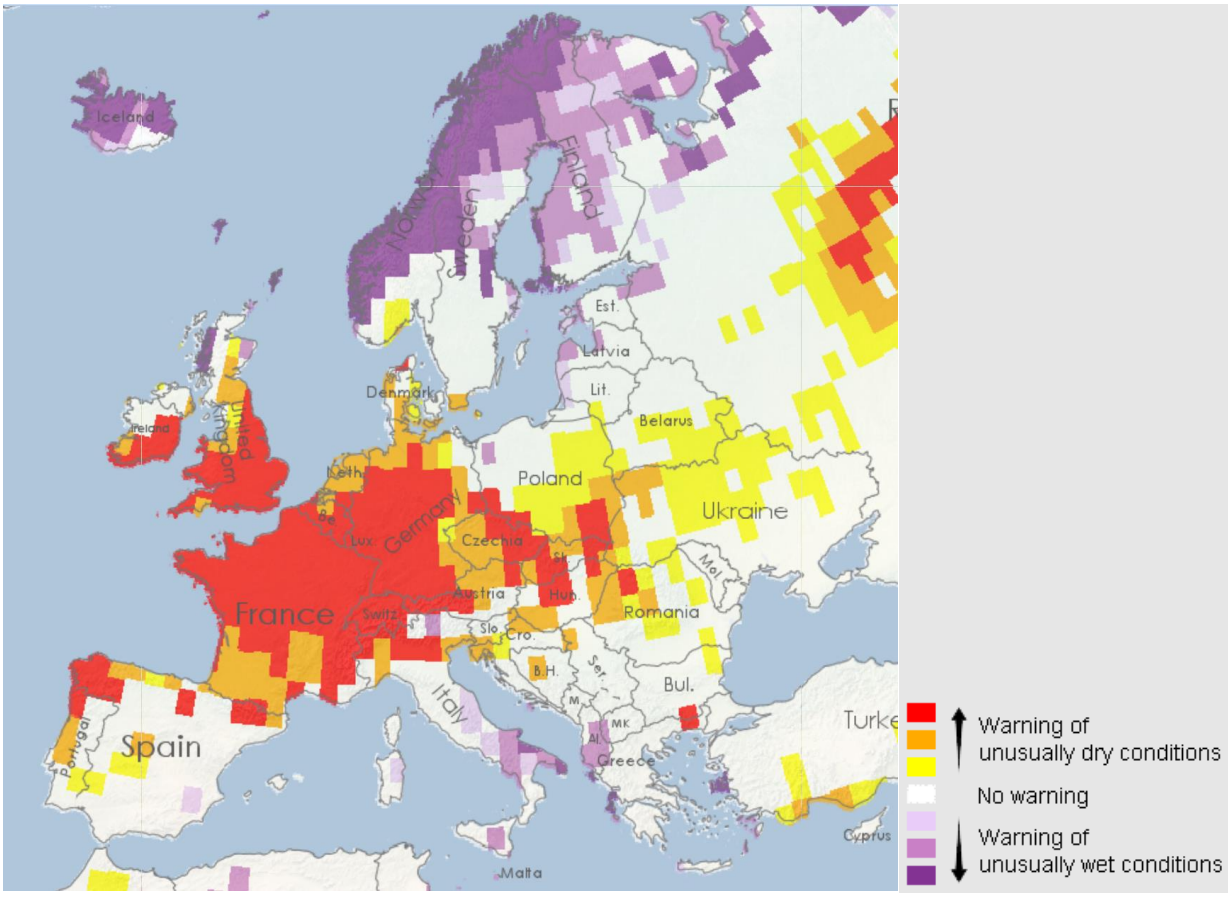

Figure 9: *Indicator for forecasting unusually wet and dry conditions from July to September 2022 (based on ECMWF SEAS5).*

[2] https://climate.copernicus.eu/seasonal-forecasts

Reported impacts

According to the June edition of the JRC MARS Bulletin on Crop Monitoring in Europe[3], water stress and heat stress, alone or combined, are driving crop yields further down from a previous already negative outlook for cereals and other crops. This reduced expectation affects in particular: France, Romania, Spain, Portugal, Italy, and to some extent Germany, Poland, Hungary, Slovenia and Croatia. In Italy, both winter and summer crops have already been negatively impacted by drought and heat stress. In France, only winter crops have been impacted so far. In Spain, both winter and summer crops have been negatively affected by rain deficit and very hot temperature. In Germany and Poland, the lack of precipitation has been affecting the yield potential of winter crops and the growth of summer crops. The yield potential of winter and spring crops has been also reduced in Romania and Ukraine, as well as in Slovakia and Hungary.

In Italy, the Po river Basin Authority classified the current situation at the highest level of drought severity, including a record-breaking inland salt intrusion from the Po delta[4]. Drought emergency was declared officially for five Italian regions[5], home to 42% of Italian population and producing 51% of national GDP[6]. Water restrictions were introduced in hundreds of municipalities, mostly in the north of the country (Po basin). Insufficient water availability led to a reduction or halt of operations for both hydro- and thermos-electric power production[7], with energy potential stored in water reserves locked at about half of the observed amount in the last few years in the north[8].

In France, 68 *Départments* are under water-use restrictions (8 July 2022)[9]. High temperatures and water deficit strongly affected primarily crops in the southern and western regions where

[3] https://op.europa.eu/s/wvGy
[4] https://www.adbpo.it/emergenza-siccita-distretto-del-po-portate-ancora-molto-basse-prelievo-non-ridotto-cuneo-salino-a-quota-record-306-km-e-assenza-di-piogge-con-temperature-altissime/
[5] https://www.protezionecivile.gov.it/it/comunicato-stampa/protezione-civile-lo-stato-di-emergenza-la-siccita-e-una-prima-tappa-
[6] http://dati.istat.it

[7] https://www.ilsole24ore.com/art/la-grande-magra-po-ferma-centrali-termoelettriche-AEUb8fhB
[8] https://transparency.entsoe.eu/generation/r2/waterReservoirsAndHydroStoragePlants/show
[9] https://www.ecologie.gouv.fr/secheresse-economiser-leau

they were most advanced. The yield outlook for winter crops is overall negative. The early development stages of summer crops were also affected in May[10].

In Spain, water stored in reservoirs is at around 69% the 10-year mean for the period, while some southern regions (e.g. Andalucía and Extremadura) are estimated to be at half the 10-year mean levels[11]. Conditions are also extremely favourable for wildfires, as confirmed by EFFIS[14].

In Portugal, hydroelectric energy stored in water reservoirs is at half the average of the previous seven years[12]. The status of water storage for irrigation is mixed, but should suffice to complete the current crops cycle[13]. Hazard of forest fires is high-to-extreme over most of the country[14].

Energy

The latest data from the ENTSO-E Transparency Platform (Fig. 10) shows that the generation from run-of-river plants in the period week 1-26 (until the beginning of July) was lower than the 2015-2021 mean for many European countries, especially for: Italy (-5059 GWh compared to the average), France (-3930 GWh) and Portugal (-2244 GWh). A similar situation holds for the reservoir levels, nine out of thirteen countries have hydropower reservoirs experiencing a decrease in levels compared to the same period in the previous years: Norway -8% (-4590 GWh), Spain -29% (-3060 GWh), Portugal -52% (-1080 GWh), Italy -25% (-929 GWh), Serbia -47% (-220 GWh), Romania -5% (-130 GWh), Montenegro -30% (-100 GWh), France -2% (-55 GWh), Bulgaria -0.1% (-2 GWh). These latest data suggest that operators had difficulties in filling the storages and, at the same time, have tried to maximise the use of the hydropower generation to satisfy the growing national demand considering its lower cost compared to the rest of the production assets.

[10] https://op.europa.eu/s/wvGy

[11] https://www.embalses.net/
[12] https://transparency.entsoe.eu/generation/r2/waterReservoirsAndHydroStoragePlants/show
[13] https://sir.dgadr.gov.pt/reservas
[14] https://effis.jrc.ec.europa.eu/apps/effis_current_situation/

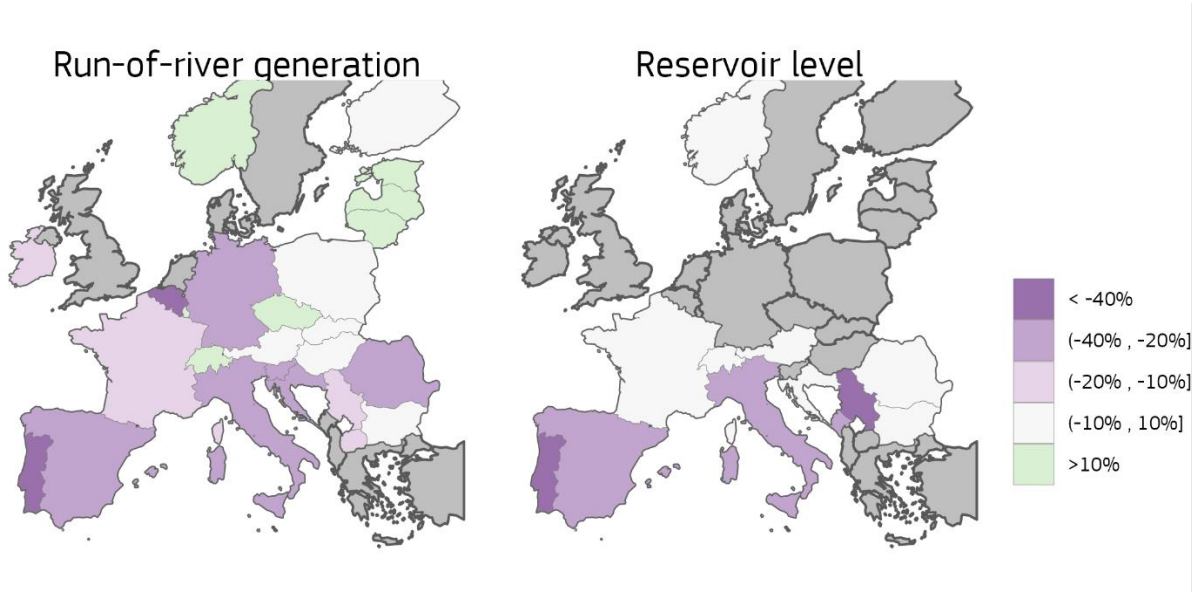

Figure 10: Difference (%) between the cumulative hydropower run-of-river generation and storage levels for the week 26 of 2022 compared to the 2015-2021 mean (same week). Data from the ENTSO-E Transparency Platform (retrieved 11/07/2022).

The Italian hydropower generation has been particularly affected by the drought, especially in the northern part of the country, where most of the installed capacity is located. The water levels in many Italian reservoirs are below the minimum historical values (considering the period 1970-2019) since September 2021 (monthly bulletins data from Terna S.p.A[15]). At the beginning of May 2022 (when the latest bulletin has been published), the stored energy value in the Italian reservoirs was 2576 GWh, i.e. 39.5% the total storage capacity *vs.* a historical (1970-2019) observed minimum of 29% for the same period. The Italian transmission system operator provides statistics at national level only, but the weekly level of the storages is also available at subnational level (bidding zones). Figure 11 shows the level of the hydropower reservoirs in the North bidding zone[16] for the years 2015-2022. The latest data show an amount of stored energy of 1375 GWh at week 26, 34.8% less than the 8-year minimum (2110 GWh in 2021). The low level of the European hydropower reservoirs may exacerbate the current situation of the European power markets which are already experiencing record-breaking wholesale prices.[17]

[15] https://www.terna.it/en/electric-system/publications/monthly-report
[16] The North bidding zone includes the following Italian regions: Valle d'Aosta, Piemonte, Lombardia, Veneto, Liguria, Friuli Venezia-Giulia, Trentino Alto Adige, Emilia-Romagna
[17] European Commission Joint Research Centre Directorate C: Energy, Transport & Climate Unit C.7: Knowledge for the Energy Union

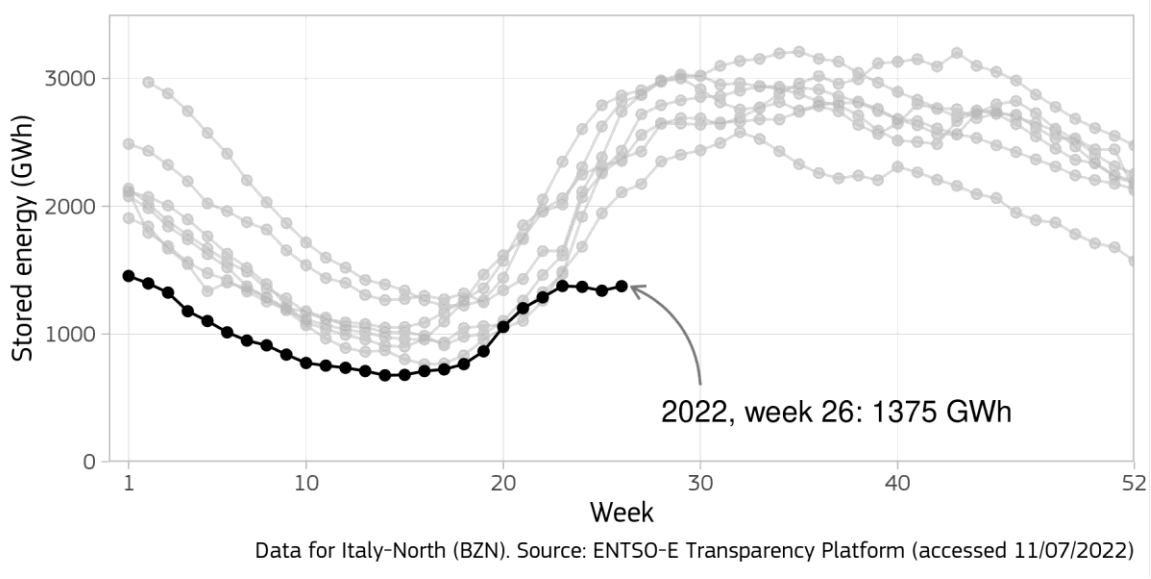

Figure 11: Hydropower storage levels in northern Italy for the period 2015-2022. Each grey line represents a specific year. The black line is associated with 2022. Source: ENTSO-E Transparency Platform.

Appendix

The Combined Drought Indicator (CDI) of the European Drought Observatory (EDO) is used to identify areas that may be affected by agricultural drought. The CDI is derived by combining the Standardized Precipitation Index (SPI), the Soil Moisture Index Anomaly (SMA), and the FAPAR anomaly. Areas are classified according to three primary drought classes: (1) "Watch", indicating that precipitation is less than normal; (2) "Warning", indicating that also soil moisture is in deficit; and (3) "Alert", indicating that also vegetation shows signs of stress. Two additional classes - "Partial recovery" and "Recovery" - identify the stages of the vegetation recovery process.

The Standardized Precipitation Index (SPI) provides information on the intensity and duration of the precipitation deficit (or surplus). 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-month period is often used to evaluate agricultural drought and the 12-month period for hydrological drought, when rivers fall dry and groundwater tables lower.

Lack of precipitation induces a reduction of soil water content. The Soil Moisture Anomaly index provides an assessment of the deviations from normal conditions of root zone water content. It is a direct measure of drought associated with the difficulty of plants in extracting water from the soil.

The satellite-based fraction of Absorbed Photosynthetically Active Radiation (FAPAR) monitors the fraction of solar energy absorbed by leaves. It is a measure of vegetation health and growth. FAPAR anomalies, and specifically negative deviations from the long-term average, are associated with possible drought impacts on vegetation.

The Low-Flow Index (LFI) is based on the daily river water discharge simulated by the LISFLOOD hydrological model. It captures consecutive periods of unusually low streamflow. It compares the consequent water deficit during those periods with the historical climatological conditions.

The indicator for 'forecasting unusually wet and dry conditions' provides early risk information for Europe. The indicator is computed from forecasted SPI-1, SPI-3 and SPI-6 derived from the ECMWF seasonal forecast system SEAS5.

Glossary of terms and acronyms:

CEMS	Copernicus Emergency Management Service
EDO	European Drought Observatory
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
EFFIS	European Forest Fire Information System
ENTSO-E	European Network of Transmission System Operators for Electricity
ERA5	ECMWF Reanalysis v5
ERCC	European Emergency Response Coordination Centre
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
GDO	Global Drought Observatory
JRC	Joint Research Centre
LFI	Low-Flow Index
MARS	Monitoring Agricultural ResourceS
SMA	Soil Moisture Index (SMI) Anomaly
SMI	Soil Moisture Index
SPI	Standardized Precipitation Index
WMO	World Meteorological Organization

EDO indicators versioning:

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

EDO Combined Drought Indicator, v.2.1.0
EDO FAPAR (fraction of Absorbed Photosynthetically Active Radiation) Anomaly, v.1.3.2
GDO Indicator for forecasting unusually wet and dry conditions v .1.0.0
EDO Low Flow Index (LFI) , v.2.1.0
EDO Soil Moisture Anomaly (SMA) (version 2.1.1) Standardized Precipitation Index SPI ERA5 (1/4-dd resolution). SPI ERA5 is a provisional dataset which replaces SPI Blended and Interpolated (v.1.2.0), unavailable in the considered period due to an issue in source data.

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

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