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Global Drought Overview September 2024

GDO Analytical Report

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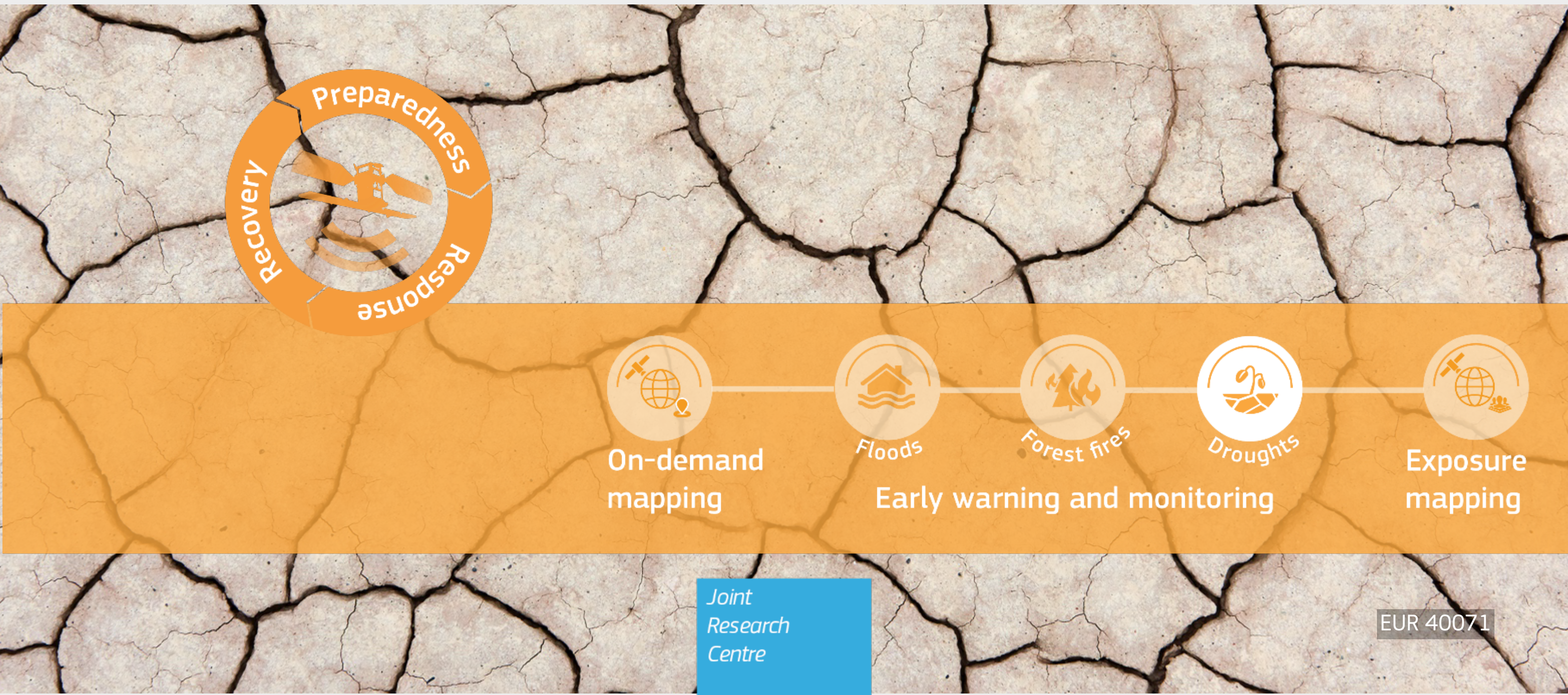
2024



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EUR 40071

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Global Drought Overview - September 2024

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - GDO data up to 31/08/2024

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Abstract

- Severe droughts are currently affecting most of South America, southern Africa and the Zambezi basin, the Mediterranean, and eastern Europe with extremely dry and warm conditions.
- Heatwaves and warm spells are exacerbating the impacts of the lack of precipitation. The average temperature is abnormally high, registering global record values in July 2024.
- Soil moisture and vegetation conditions are severely affected, with negative anomalies over large areas of the world.
- Many rivers in major basins worldwide, including the Amazon, La Plata, and Zambezi, have registered very low discharge in 2023-2024.
- The rare combination of strong positive phases of ENSO and the Indian Ocean Dipole, together with the warm phase of the Tropical North Atlantic and climate change, are likely key drivers of drought in South America, southern and central Africa, and extreme heat in South America, Africa, the Mediterranean and East Europe.
- Agricultural productivity has been affected in many regions of the world as the extreme conditions occurred during critical periods of the growing season, with severe economic and social impacts.
- Crop damages and losses have caused the IPC (Integrated Food Security Phase Classification) Acute Food Insecurity to range from stressed to crisis level in most of the monitored regions.
- Wildfire danger is high in eastern Brazil, the western U.S., southern and eastern Africa, central Asia, Australia, and eastern Europe.
- Seasonal forecasts point to warmer than average conditions in the following months. Early April 2024 precipitation shifted the seasonal forecast towards wetter values but according to May-June-July forecast dry conditions are expected after this temporary relief. Close monitoring of the drought evolution and proper water use plans are needed.

Introduction

This is part of the collection *GDO analytical reports* that is focused on the analysis of drought events affecting Europe as well as the other regions of the world. These studies build on data and information retrieved and processed within the European and Global Drought Observatories of the Copernicus Emergency Management Service. The Observatories aim at detecting, monitoring, and predicting droughts by using a suite of indices and indicators characterising different aspects and phases of a drought. The information are usually complemented with additional ones on impacts, large-scale circulation, and other relevant factors.

Standardized Precipitation Index (SPI)

Severe negative precipitation anomalies are currently affecting many parts of world. The SPI-3 (i.e. SPI for an accumulation period of 3 months) shows extremely dry conditions in most of the Amazon basin and part of the La Plata basin in South America, some regions of Mexico, most of central Africa, some regions of the Mediterranean, Ukraine and south-western Russia, south-east Asia, some northern regions in Canada and Russia. Local spots of precipitation deficit are also found in central Asia, the U.S., and southern Australia (Fig. 1).[1]

The longer accumulation SPI periods from 6 to 24 months ending in August 2024 are shown in Figure 2. These maps highlight the longer-lasting lack of precipitation affecting directly water resources, river flows and the hydrology in general. The most affected regions are in South America, northern, central and southern Africa, and some areas in the Mediterranean. Additionally, by comparing the different accumulation periods including also SPI-3 (Fig. 1), it is possible to highlight the more recent droughts (e.g. in eastern Europe and Ukraine and

[1] For more details on the SPI, and the other GDO and EDO indicators of drought-related information used in this report, see the Appendix at the end of the document.

the western part of the U.S., visible mainly in SPI-3 and/or in SPI-6) and the regions showing some recovery (e.g. southern Africa where the precipitation anomaly reduced in SPI-3). However, all the regions with extremely drier than normal SPI-24 values are severely affected by drought and in critical conditions in terms of water resources. These regions include most of South America, most of Africa (except eastern Africa), south-eastern Asia, the Mediterranean, and north-eastern North America.

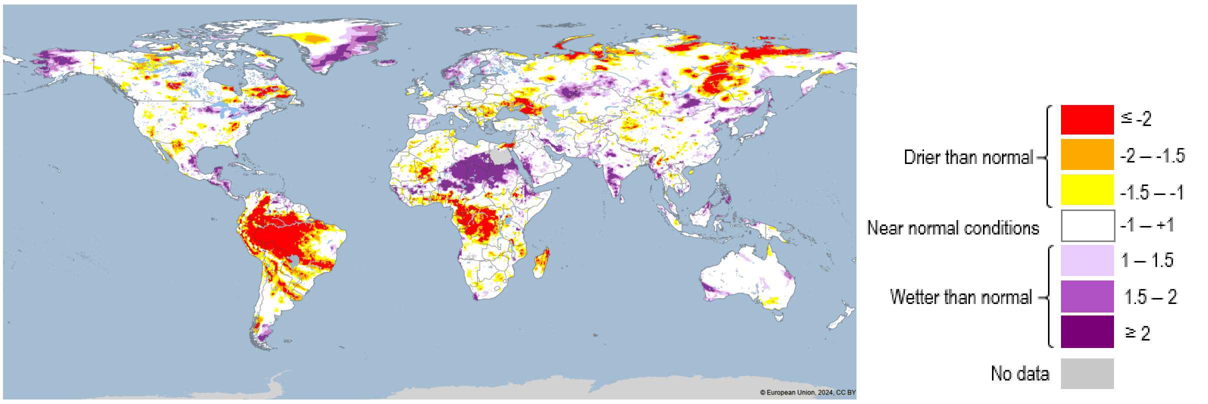

Figure 1: *Standardized Precipitation Index SPI-3 for the 3-month accumulation period ending on 31 August 2024.*[1]

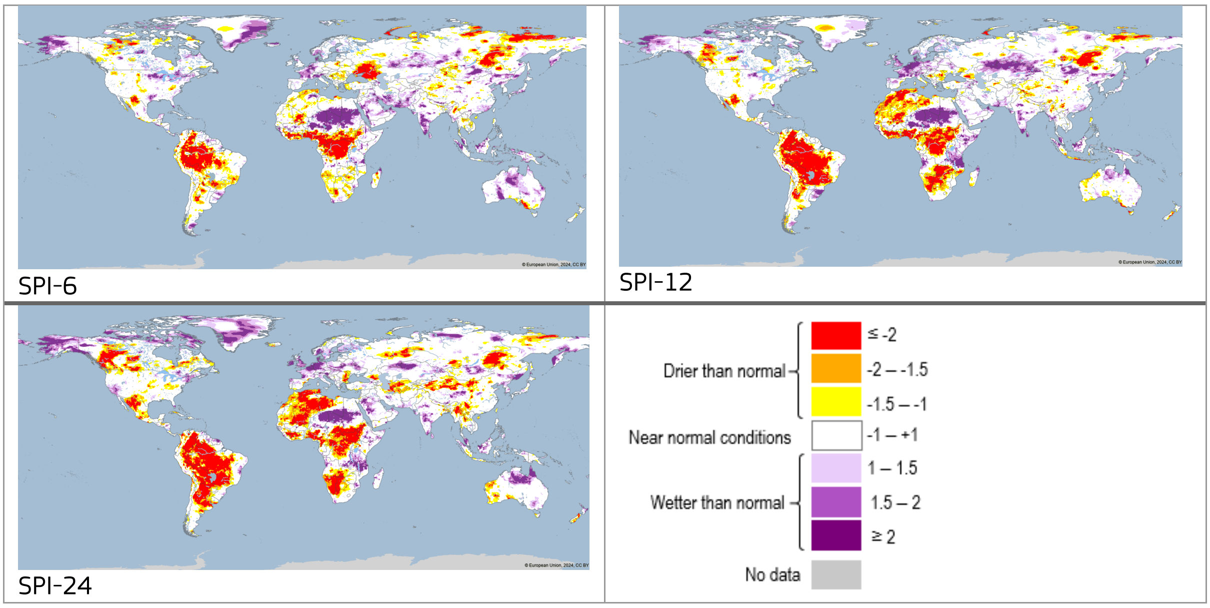

Figure 2*:* *Standardized Precipitation Index (SPI-6, 12, 24), for 6, 12, 24-month accumulation periods respectively ending on 31 August 2024.*[1]

The extent of the ongoing meteorological droughts covers wide areas including almost the whole Amazon and La Plata basin in South America, most of western Mexico, most of central and north-western Africa, Madagascar, eastern Europe and south-western Russia, most of northern Russia, and some regions in Canada. (Fig. 3). Its spatial and temporal dynamics can be estimated by using a recently developed method for tracking drought events.[2] This method is used to detect and track the spatial and temporal dynamics of drought events resulting from areas under meteorological drought conditions.

During the period August 2023 – July 2024 a total of 52 individual drought events have been detected (Fig. 4), the major and long-lasting ones being over South America, central and eastern Asia, central Africa, and North America. In South America, two previously independent major events affecting the Amazon basin and the La Plata basin in August 2023 expanded and connected until January 2024, when they split late in the months to merge again in February 2024. From April to June 2024 the Amazon one persisted and the La Plata reduced significantly in size, but from July 2024 both expanded again, eventually covering vast areas in South America. Mexico and central America have been affected by a fading out event from August 2023 to November 2023 with a new onset in April 2024. The Zambezi basin has been hit by a severe drought from November 2023 to May 2024. The Mediterranean has been almost continuously affected by drought events, in particular in its southern and eastern regions, from September 2023 to July 2024, that despite some spatial pattern changes were characterised by a strong overall persistence. Australia has been hit by a drought event that started in August 2023, rapidly expanded and covered the whole country in October 2023 and then slowly reduced mainly to the southern regions. It is worth to underline that these events are built on precipitation anomalies and detected meteorological droughts. This means that the effects and the impacts of the long and severe events persist longer and in some cases are still ongoing. Figure 4 shows in details the evolution of all the detected meteorological drought events.

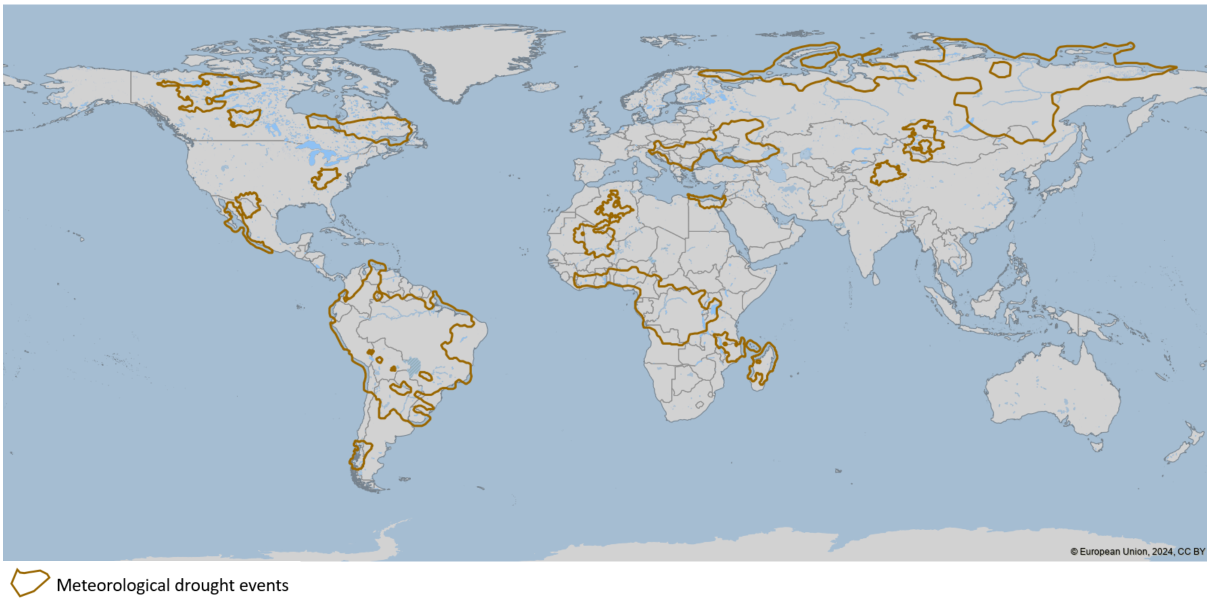

Figure 3: *Spatial-temporal tracking of the meteorological droughts in late August 2024[2]. Data source: SPI-3 data derived from the ERA5 (ECMWF Reanalysis v5) precipitation reanalysis.*

[2] The method is based on a generalized three-dimensional density-based clustering algorithm (DBSCAN). See: Cammalleri, C., and A. Toreti, 2023: A Generalized Density-Based Algorithm for the Spatiotemporal Tracking of Drought Events. J. Hydrometeor., 24, 537–548, https://doi.org/10.1175/JHM-D-22-0115.1.

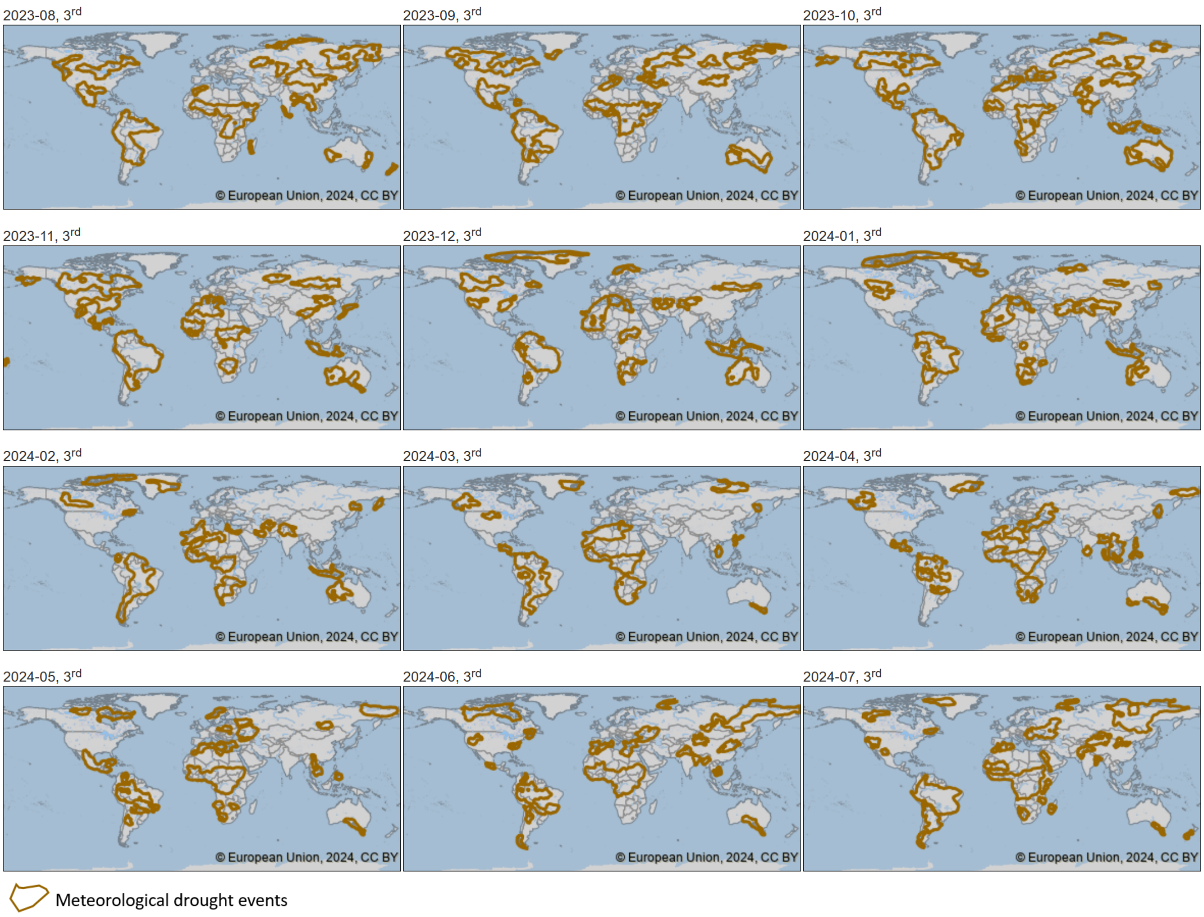

Figure 4: *Spatial-temporal tracking of the meteorological droughts from late August 2023 (upper left panel) to late July 2024 (bottom right panel)[2]. Data source: SPI-3 data derived from the ERA5 precipitation reanalysis.*

The impacts and the evolution of meteorological drought events are directly connected with the amplitude of the precipitation anomaly but even more with its persistence. This kind of information, already indicated by the longer accumulation period of the SPI (SPI-12 and SPI-24), can be also retrieved by considering the total persistence estimated by the drought tracking algorithm. This variable shows the count of 10-day periods when a pixel is identified as part of (at any moment during August 2023 and August 2024) a meteorological drought event.

Figure 5 clearly shows that drought events have persisted for most of the analysed period in the Amazon and La Plata basins (Aug 2023 – Aug 2024) and the longest persistence occurred in South America, central and northern Africa. Other regions with high drought persistence are: western Africa, the Zambesi basin, eastern Australia, Mexico and Central America, the Mediterranean, some regions in Canada and Russia.

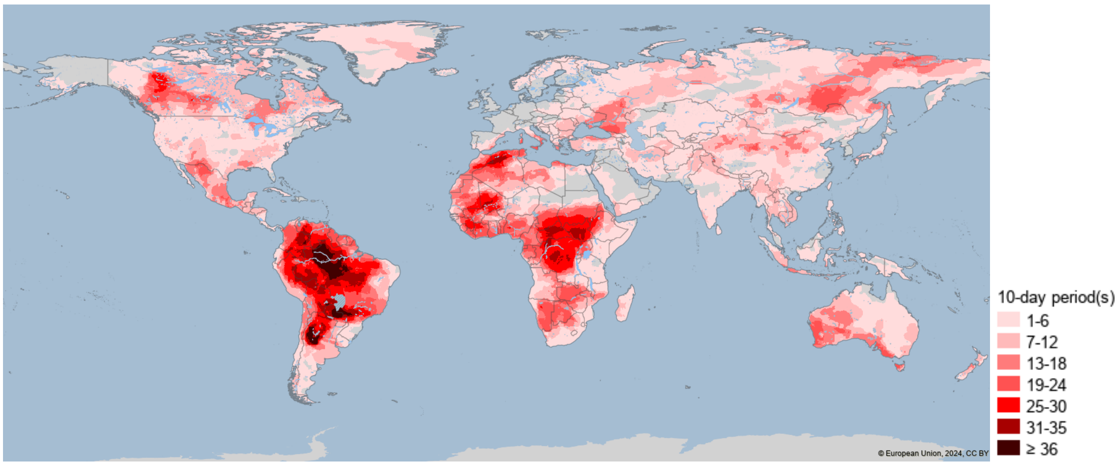

Figure 5: *Total persistence estimated by the meteorological drought tracking in the period Aug 2023 – Aug 2024.* [2]

Temperature

July 2024 has been warmer than average (baseline 1991-2020) in many regions of the world. North-western North America, eastern Canada, the Mediterranean, eastern Europe, south-eastern and central Africa, Iran, western and central Russia, and Japan experienced higher than 3 °C for the July 2024 average temperature anomalies. In Antarctica, the monthly temperature anomalies for July 2024 have been above +5 °C in most of the regions (Fig. 6). The daily global average temperature reached a new record of 17.16 °C on 22 July 2024, according to the ERA5 dataset. This has been the warmest day in the recent history according to the Copernicus Climate Change Service (C3S)[3]. August 2024 has been very similar to the previous month, with the main differences being the positive anomaly in Australia (up to +4 °C) and northern Scandinavia (up to +5 °C), and the negative anomaly in Chad and Sudan (Fig. 6). August 2024 has been the joint-warmest August globally (together with August 2023), according to the Copernicus Climate Change Service (C3S)[4]

The yearly average temperature anomalies (September 2023 - August 2024) have been almost everywhere positive, with very few exceptions (e.g. southern South America, Scandinavia). Northern North America, central South America, central-eastern Europe, the Mediterranean, central-eastern Africa, central southern China, northern Russia, and some regions in Antarctica experienced yearly anomalies higher than 2 °C (Fig. 7).

[3] https://climate.copernicus.eu/new-record-daily-global-average-temperature-reached-july-2024

[4] https://climate.copernicus.eu/surface-air-temperature-august-2024

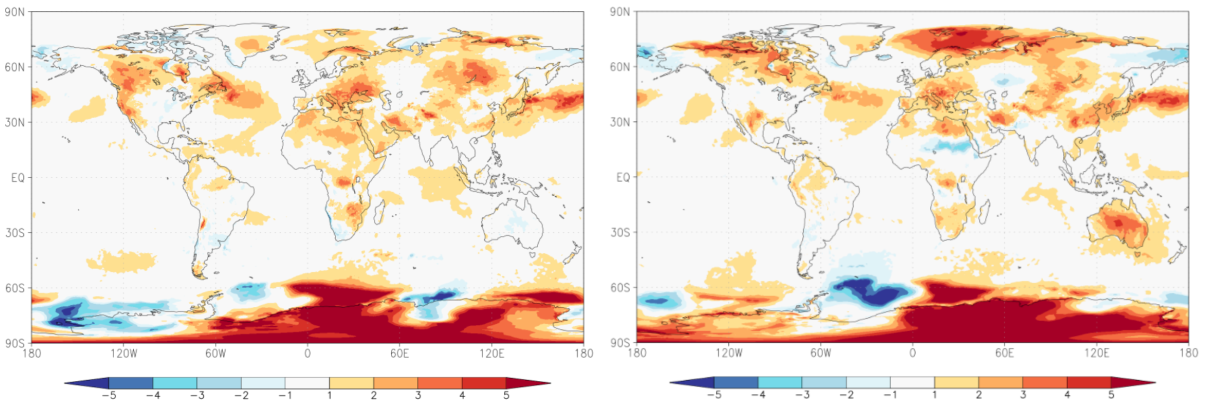

Figure 6: *Average temperature anomaly (ERA5) computed for July 2024 (left) and August 2024 (right). Baseline 1991-2020. Source: The KNMI (Koninklijk Nederlands Meteorologisch Instituut) Climate Explorer.*[5]

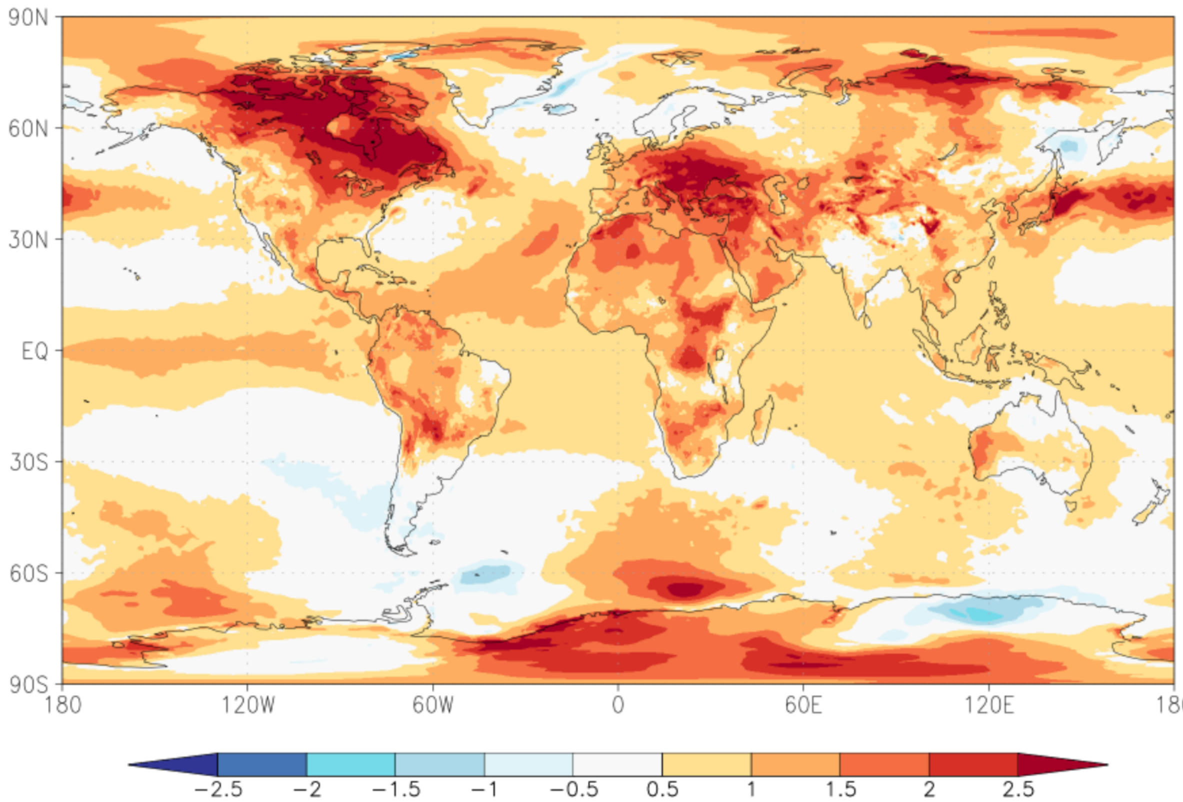

Figure 7: *Average yearly temperature anomaly (ERA5) computed for the period September 2023 - August 2024 (baseline 1991-2020). Source: The KNMI Climate Explorer.*[5]

Persistent positive temperature anomalies were also associated with heatwaves and warm spells. Once an event is detected, two main characteristics can be derived: its duration and intensity. The duration is simply the

[5] The KNMI Climate Explorer https://climexp.knmi.nl

count of the consecutive days belonging to the event. The intensity is calculated as the sum of the temperature anomalies relative to the 0.9 climatological quantiles throughout the event. It is worth to highlight that this definition reflects the magnitude of the temperature anomaly, rather than the extreme values of the absolute temperatures[6].

In August 2024, the longest events hit the northern regions of South America, the southern U.S., most of the Mediterranean, eastern Europe, central Africa, central Asia, south-east Asia, central Australia, and Antarctica with maximum duration almost equal to 31 days (Fig. 8). In terms of intensity, the most severe events in August 2024 hit the Mediterranean, central Asia, northern Europe, northern Canada, central Australia, and Antarctica (Fig. 9). In Antarctica, a prolonged and significant mid-winter increase in temperatures compared to prior winters, caused several regions of the continent to reach record temperatures anomalies.

Figure 10 shows the sequence of monthly duration maps from August 2023 to August 2024. According to the results, North America experienced long-lasting events mainly from August to October 2023; South America was affected throughout the entire period, with the largest extent of long-lasting heatwaves in November-December 2023; the Mediterranean and central-southern Africa were affected primarily from August 2023 to November 2023 and from April 2024 to July 2024; Asia experienced alternate months with and without heatwaves/warm spells.

Similar spatial and temporal patterns characterize the monthly intensity maps (Fig. 11). The highest ones have been detected in August-October 2023 for central-eastern Africa, in October-November 2023 for South America, in January-February 2024 for north-eastern North America, and in April-June 2024 for central Africa. The Mediterranean area has been hit by a sequence of intense heatwaves and warm spells in August-September 2023, February 2024, April 2024, and June-July 2024.

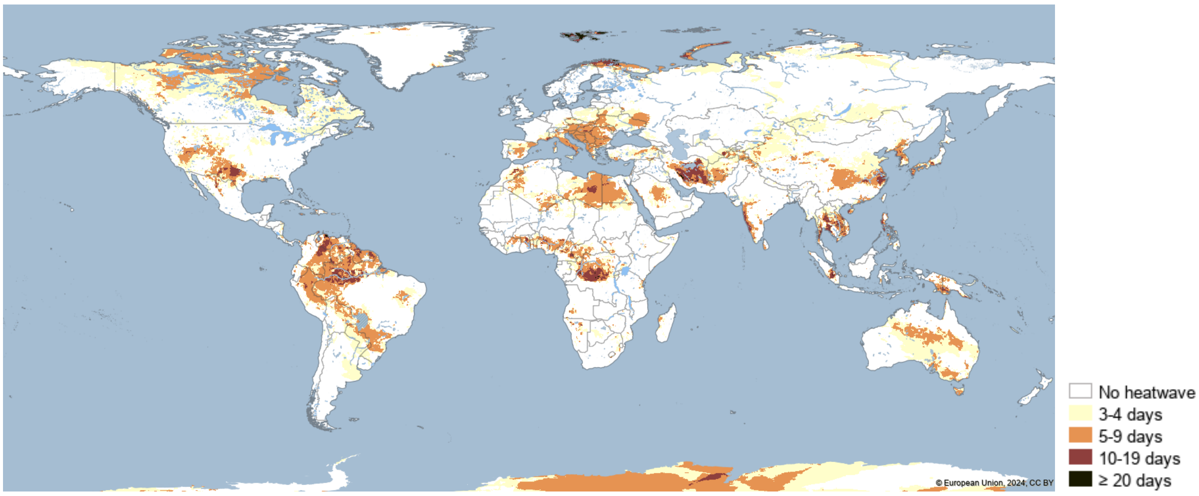

Figure 8: *Maximum duration of the heatwaves/warm spells detected in August 2024. In this case, the maximum duration of an event cannot exceed the number of days in a given month.*

[6] Lavaysse, C., Cammalleri, C., Dosio, A., van der Schrier, G., Toreti, A., and Vogt, J.: Towards a monitoring system of temperature extremes in Europe, Nat. Hazards Earth Syst. Sci., 18, 91–104, https://doi.org/10.5194/nhess-18-91-2018, 2018.

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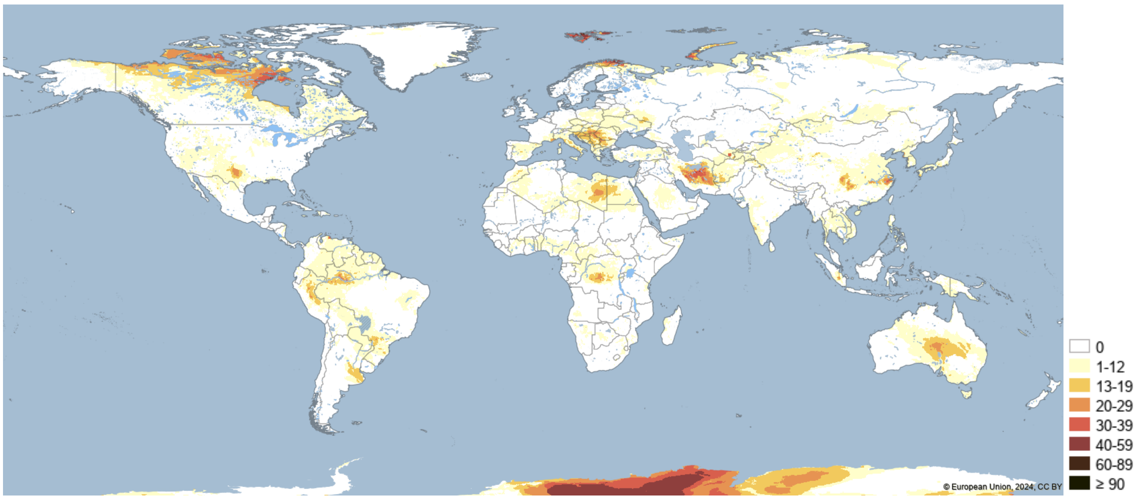

Figure 9: *Maximum intensity of the heatwaves/warm spells detected in August 2024.*

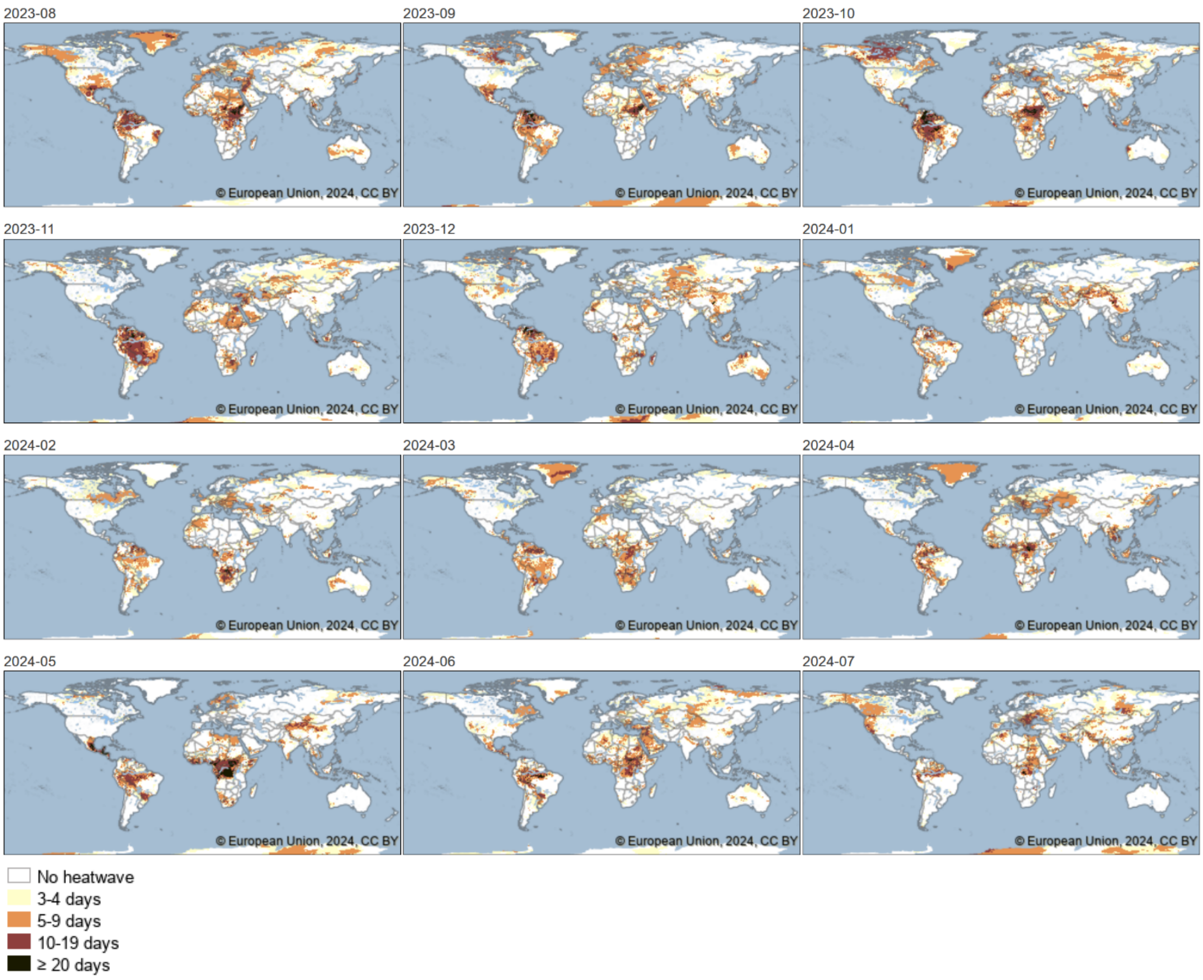

Figure 10: *Maximum duration of the heatwaves/warm spells detected in each month of the period from August 2023 to July 2024. In this case, the maximum duration of an event cannot exceed the number of days in a given month.*

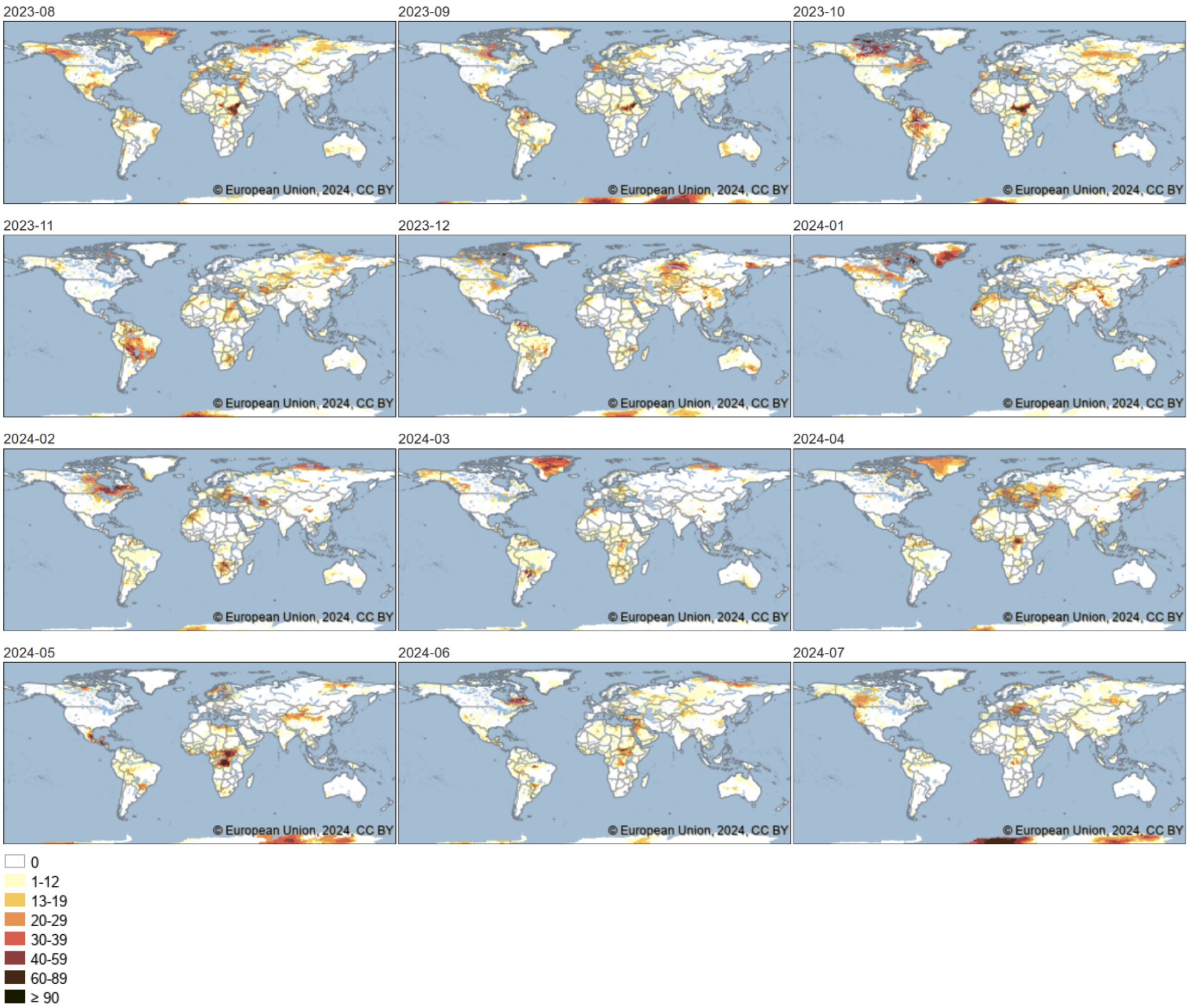

Figure 11: *Maximum intensity of the heatwaves/warm spells detected in each month of the period from August 2023 to July 2024.*

Throughout the whole period from August 2023 to August 2024, the longest heatwaves/warm spells have been detected for central-northern South America, some regions in central America, southern Mexico, and central Africa, with maximum durations exceeding 2 months (Fig. 12). The intensity map shows that the most severe events in the same period occurred in central-northern South America, some regions in central America, central-southern Mexico, central Africa, eastern Mediterranean, southern Africa, north-eastern Canada, and northern Russia (Fig. 13).

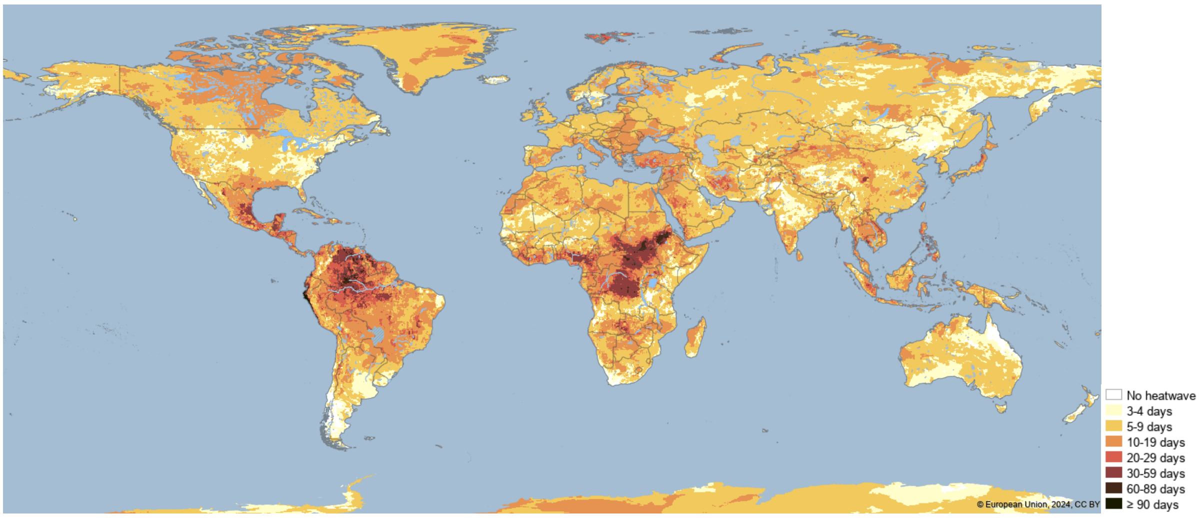

Figure 12: *Maximum duration of the heatwaves/warm spells detected during the period from August 2023 to August 2024.*

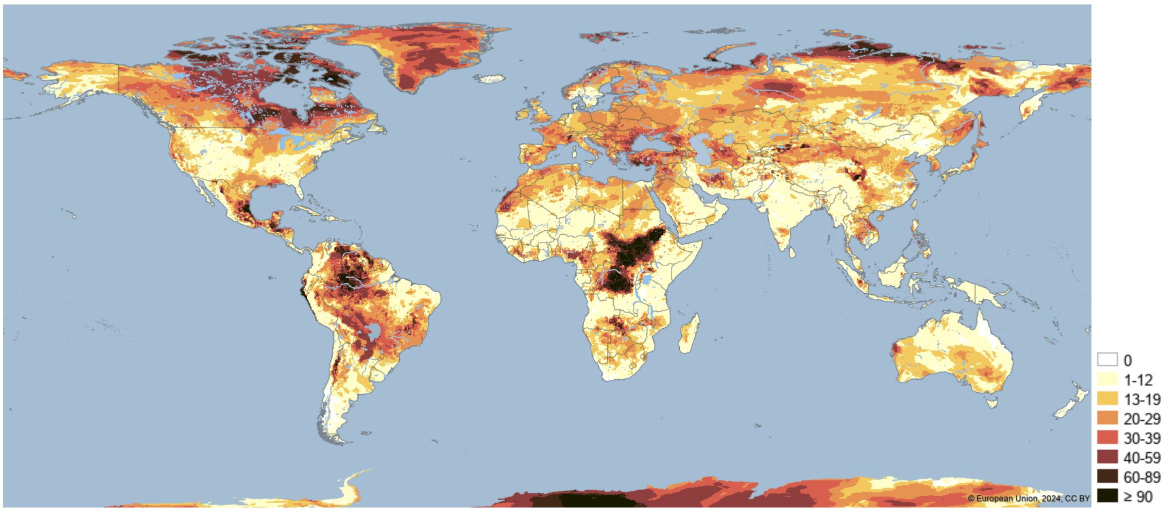

Figure 13: Maximum intensity of the heatwaves/warm spells detected during the period from August2023 to August 2024.

Soil moisture and groundwater

In late August 2024, soil moisture anomalies have been remarkably negative over almost the whole Amazon basin, most of the La Plata basin, large regions in central and western Africa, and most of northern Africa. In the Zambesi basin, eastern Europe, eastern Russia, northern Mexico, and western Canada anomalies were negative but with less severe values (Fig. 14). These conditions are the result of a combination of extremely low precipitation and high temperatures in the previous months. The drier-than-normal soil moisture pattern is consistent with the precipitation deficit of the previous months (see Fig. 1). Moreover, the regions with the strongest negative precipitation anomalies were also affected by positive temperature anomalies. These compound factors contributed to an exacerbated water loss from the soil due to stronger evapotranspiration potential. Indeed, large areas in South America and Africa show soil moisture anomalies below -2, corresponding to the driest class of the GDO indicator (Fig. 14).[7]

Concerning the evolution of soil moisture anomalies (Fig. 15), a strong spatial and temporal variability is depicted. Northern America was affected by a fading out drought from August 2023 to December 2023. In central America and Mexico, a similar trend is observed but the drought lasted longer (January 2024) and then worsened again in May-June 2024. South America has been almost continuously affected by dry soil moisture with only few local and temporary recovery (e.g. in eastern Brazil in March 2024). In southern Africa drought initially slightly affected southern Angola and northern Zambia (October - November 2023), then expanded to wide regions of the Zambezi basin, south-western South Africa and southern Madagascar (December 2023). In January 2024 there has been a temporary reduction of the extent and the severity of the drought with near-normal conditions almost for the whole southern African countries. In March – April 2024 soil moisture conditions rapidly deteriorated reaching the most severe drought value over the whole Zambezi basin and south-eastern South Africa. Finally, from May 2024 drought conditions persisted but with less extreme values in southern African regions. The Mediterranean, and in particular northern Africa, has been almost continuously affected by dry condition from October 2023 to June 2024. Eastern Europe and the Black Sea regions have been hit by drought from April to July 2024. An intense a long-lasting event affected south-east Asia from August 2023 to late 2023, slowly improving and alternatively worsening till July 2024. Missing data are due to the satellite component of the ensemble.

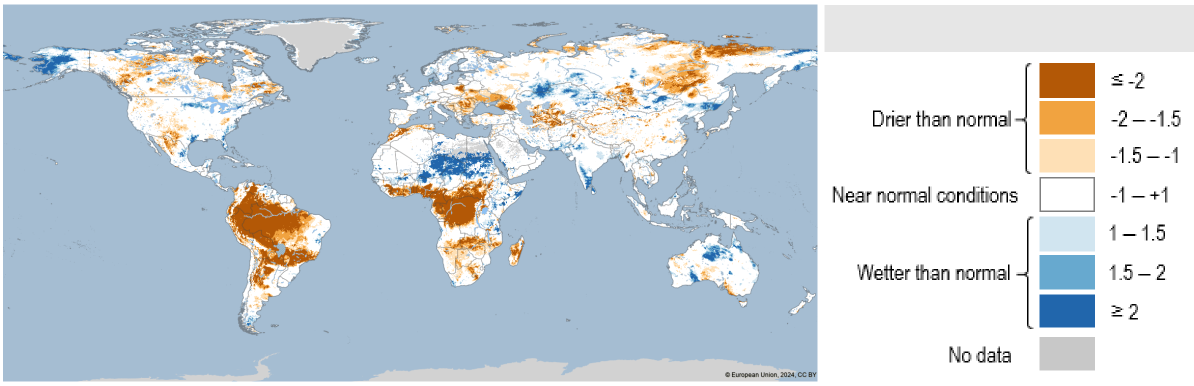

Figure 14: *Soil Moisture Anomaly, late August 2024.*[7]

[7] For more details on the Soil Moisture Anomaly, and the other GDO and EDO indicators of drought-related information used in the report, see the Appendix at the end of the document. Note that the map of the latest Soil Moisture Anomaly in figure 14 has been produced using a provisional product including only the modelled data from Lisflood model. A new updated version of the ensemble product is under development. The maps in figure 15 are derived from an ensemble of Lisflood model and satellite data from the ESA Climate Change Initiative for Soil Moisture (https://cds.climate.copernicus.eu/portfolio/dataset/satellite-soil-moisture)

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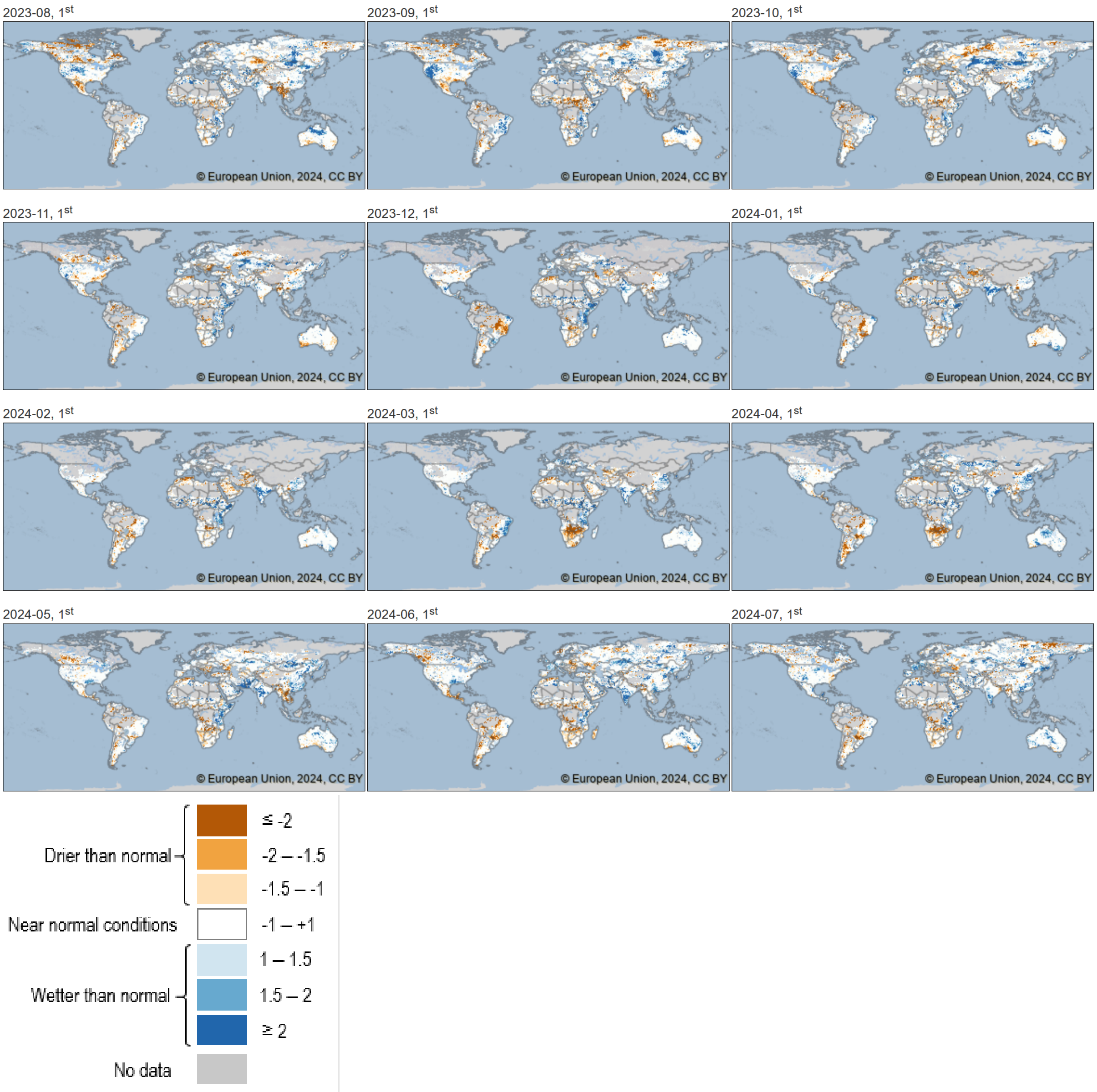

Figure 15: *Soil Moisture Anomaly, 10-day periods from August 2023 to July 2024.*[7]

The Total Water Storage (TWS) Anomaly indicator is used for determining the occurrence of long-term hydrological drought conditions and is often used as a proxy of substantial lowering of the groundwater level. This indicator is computed as anomalies of TWS data derived from the GRACE (Gravity Recovery and Climate Experiment) twin satellites.[8]

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

The TWS anomaly has a good correlation with long-term SPI (12, 24, 48 months).[9] In May 2024, large areas of South America, Mexico, western Canada, the Mediterranean, the Zambezi basin, and central Asia were suffering from severe negative anomalies (Fig. 16).[10]

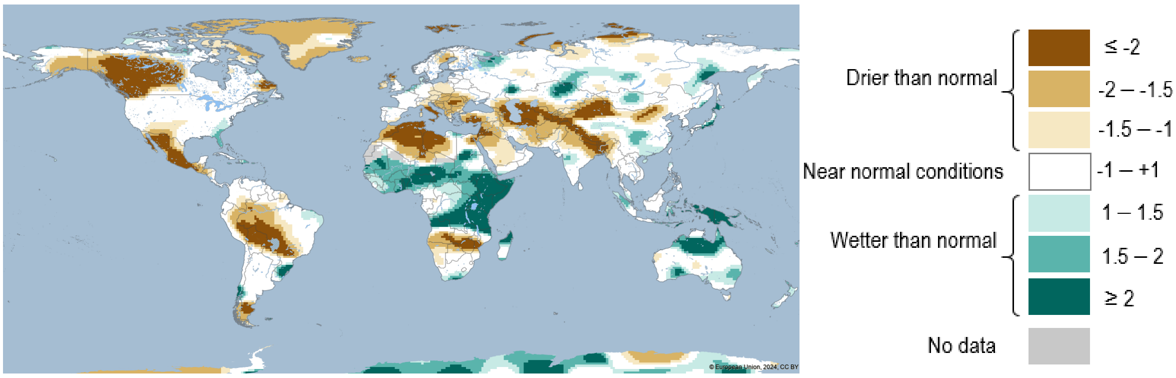

Figure 16: *GRACE-derived Total Water Storage (TWS) Anomaly, for May 2024.*[10]

Figure 17 shows the evolution of TWS anomaly from May 2023 to April 2024. In North America dry conditions have been stable with the worst conditions in western Canada. In Mexico dry conditions started in July 2023 and have never really recovered. In South America after a normal period (May-September 2023) from October 2023 onward dry conditions affected the Amazon and La Plata basins. The Mediterranean has been continuously dryer than normal with continuous worsening conditions. The Zambezi basin started to show dry conditions since March 2023. Central Asia has been almost always drier than normal.

[9] 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.

[10] For more details on the GRACE-derived Total Water Storage (TWS) Anomaly indicator, and the other GDO and EDO indicators of drought-related information used in the report, see the Appendix at the end of the document.

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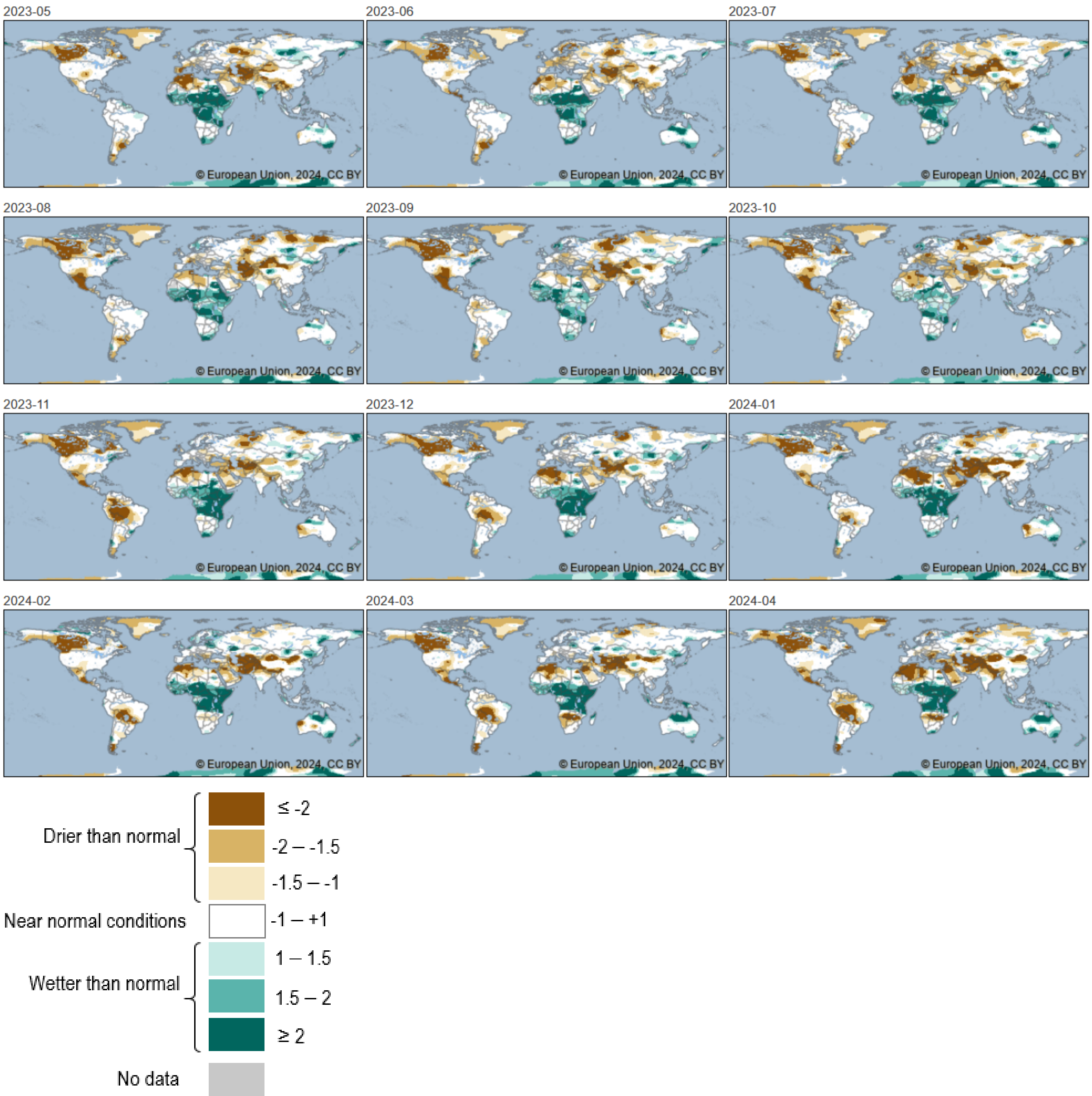

Figure 17: *GRACE-derived Total Water Storage (TWS) Anomaly, from May 2023 to April 2024.*[10]

Vegetation biomass

In late August 2024, the satellite-derived fAPAR (Fraction of Absorbed Photosynthetically Active Radiation) anomaly indicator[11] shows vegetation stress over western North America, central South America, central-southern Africa, the Mediterranean, eastern Europe, Indonesia, and some regions in Australia (Fig. 18).

[11] For more details on the satellite-derived Fraction of Absorbed Photosynthetically Active Radiation (fAPAR) anomaly indicator, and the other GDO and EDO indicators of drought-related information used in the report, see the Appendix at the end of the document.

The evolution of the fAPAR anomaly from August 2023 to July 2024 (Fig. 19) indicates variable vegetation stress conditions, with relevant spatial differences. Alternating worsening and improvement conditions are visible in particular in southern America, Mexico, central and southern Africa, central Asia, India and south-western Australia in the period October 2023 – February 2024. Afterwards, a general worsening of the vegetation conditions is visible, initially (March - April 2024) with a strong reduction of the regions with higher than normal photosynthetic activity and then (May-July 2024) with a visible increase in regions under poor vegetation conditions, particularly in the Boreal Hemisphere and in most of Africa. In July 2024, the regions affected by poor vegetation conditions reached the maximum extent, including simultaneously most of the globe.

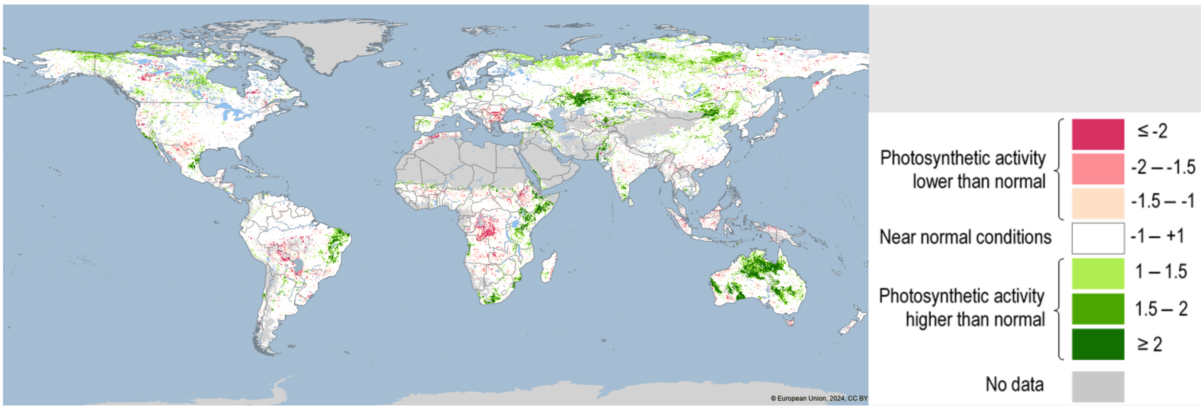

Figure 18: *Satellite-derived fAPAR anomaly indicator (measuring photosynthetic activity of vegetation) in late August 2024.*[11]

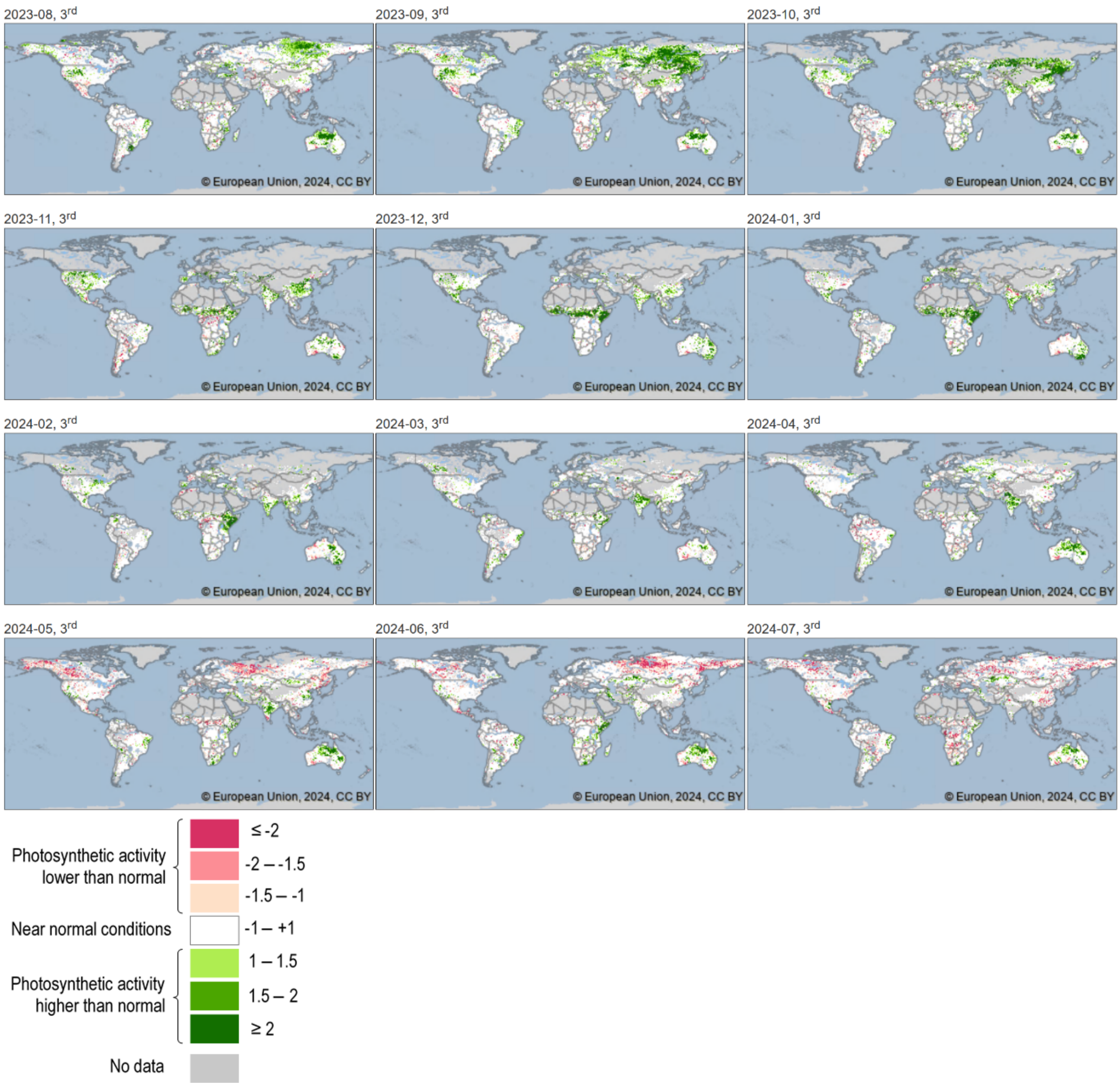

Figure 19: *Satellite-derived fAPAR anomaly indicator (measuring photosynthetic activity of vegetation) at the end of each month from August 2023 to July 2024.* [11]

Large-scale drivers

The period between August 2023 and July 2024 has been exceptional from a climatological point of view. The global mean temperature hit a record high since preindustrial times and was about 0.75 K warmer than the 1991-2020 mean, showing a rapid warming of over 0.3 K since the precedent 12-month period (Fig. 20). Despite a large uncertainty, linear trends in SPI12 since 1980s show a drying in most of South America, parts of southern, central and northern Africa, many of which coincide with drought affected regions since August 2023 (Fig. 20). Furthermore, temperature trends also coincide with areas affected by drought and extreme temperature, particularly in eastern Europe, the Mediterranean and northern Africa (>0.5 K/decade).

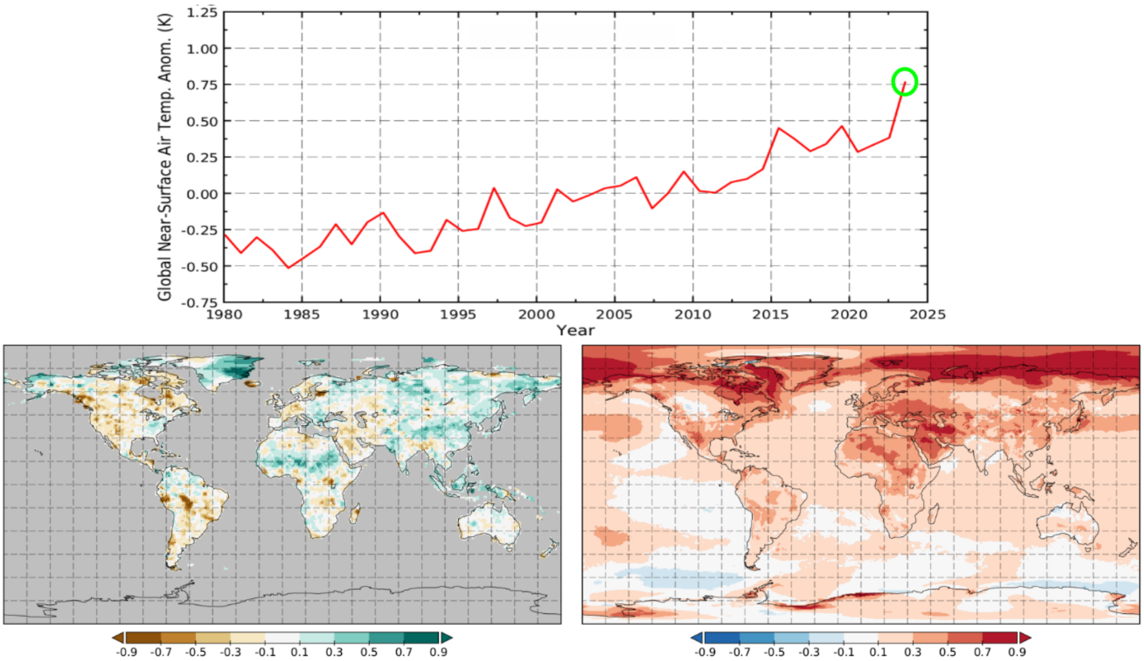

Figure 20: *Top panel: Mean annual global near-surface air temperature computed between August and the following July. Bottom panel, left: Linear trend (1/decade) of the July SPI12 between 1981-2023. Bottom panel, right: Linear trend (K/decade) of the August to July near-surface temperature in the period 1981-2023. The green circle highlights the value for August 2013 – July 2024. Sources: GPCC for precipitation and ERA5 for temperature.*

Apart from the gradually evolving shifts in hydroclimatic conditions induced by climate change, the combination of two major natural climate modes of variability aligned in the period August 2023 – July 2024: The positive phases of El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) together with the warm phase of theTropical North Atlantic (TNA). The steep increase in global temperature after the second half of 2023 may be partly caused by the development of a strong El Niño in the tropical Pacific (Fig. 21) and unprecedented warm anomalies in the tropical North Atlantic (Fig. 22). The Indian Ocean Dipole was also in an extreme positive phase during the same period (Fig. 23).

Linear regression analysis of detrended variables shows that during positive ENSO (El Niño) years (August to next July), tropical Central and South America, southern and central Africa, the Maritime Continent, Southeast Asia and Australia tend to be both drier and hotter than usual (Fig. 21). During the warm phase of the TNA, the northern half of South America tends to be drier and hotter than usual, while North Africa and most of the regions in the tropical band are warmer than usual. It is noteworthy to mention that after detrending, the TNA was in an unprecedented state in August 2023-July2023 of almost four standard deviations above the long-term mean. The IOD was also in an extreme positive phase only smaller to the August 2019 – July 2020 period. During positive IOD phases southern Africa, the Maritime Continent, Southeast Asia and Australia tend to be both drier and hotter than usual (Fig. 23).

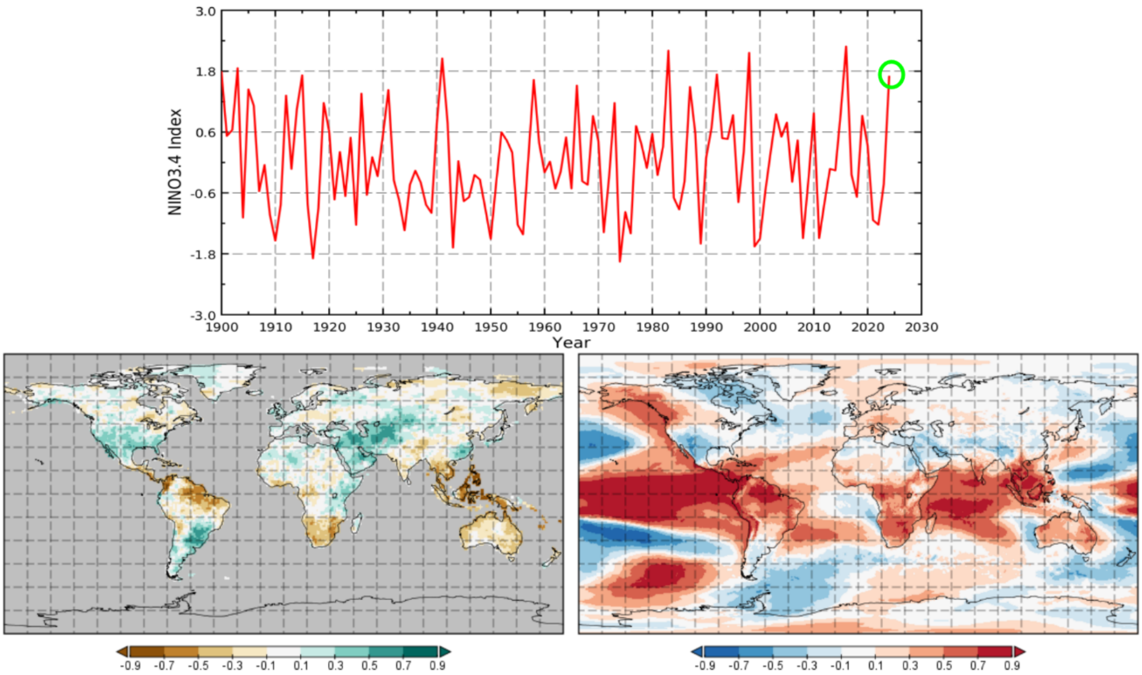

Figure 21: *Top panel: linearly detrended and standardized sea surface temperature average in the NINO3.4 region since 1900 for the 12-month mean between August and the following July. Bottom panel, left: linear regression coefficient (1/K) of the July SPI12 and the NINO34 Index between 1981-2023. Bottom panel, right: linear regression coefficient (K/K) of the August to July near-surface temperature and the NINO34 Index between 1981-2023 The green circle highlights the value for August 2023 – July 2024. Sources: ERSSTv5 for sea surface temperature NINO34, GPCC for precipitation and ERA5 for temperature.*

These three important climate modes of variability modulate temperature and precipitation patterns in many regions of the world on seasonal to annual timescales. Note also these climatic indices are not mutually independent but can exert remote influences on each other. They may also nonlinearly induce changes in hydroclimatic conditions. Furthermore, they are not a comprehensive selection meaning that other factors could be behind the observed droughts since the boreal summer of 2023. For instance, it is not clear how the combination of positive ENSO and IOD indices (which tend to induce drought in Southeast Asia, Australia and the maritime Continent) had little impact in those regions during the period August 2023 – July 2024. Despite uncertainty, the rare combination of ENSO, TNA and IOD indices in strong positive phases, superimposed to a background of climate change are very likely drivers of drought and extreme heat conditions in South America and southern and central Africa and possibly also impacting temperatures in the Mediterranean, eastern Europe and northern Africa. For further information on ENSO, TNA and IOD definition, global teleconnections, and impacts see for example Alizadeh (2024)[12], Jiang and Li (2022)[13], and Saji and Yamagata (2003)[14].

[12] https://wires.onlinelibrary.wiley.com/doi/full/10.1002/wcc.861

[13] https://journals.ametsoc.org/view/journals/clim/34/14/JCLI-D-20-0835.1.xml

[14] https://www.int-res.com/abstracts/cr/v25/n2/p151-169

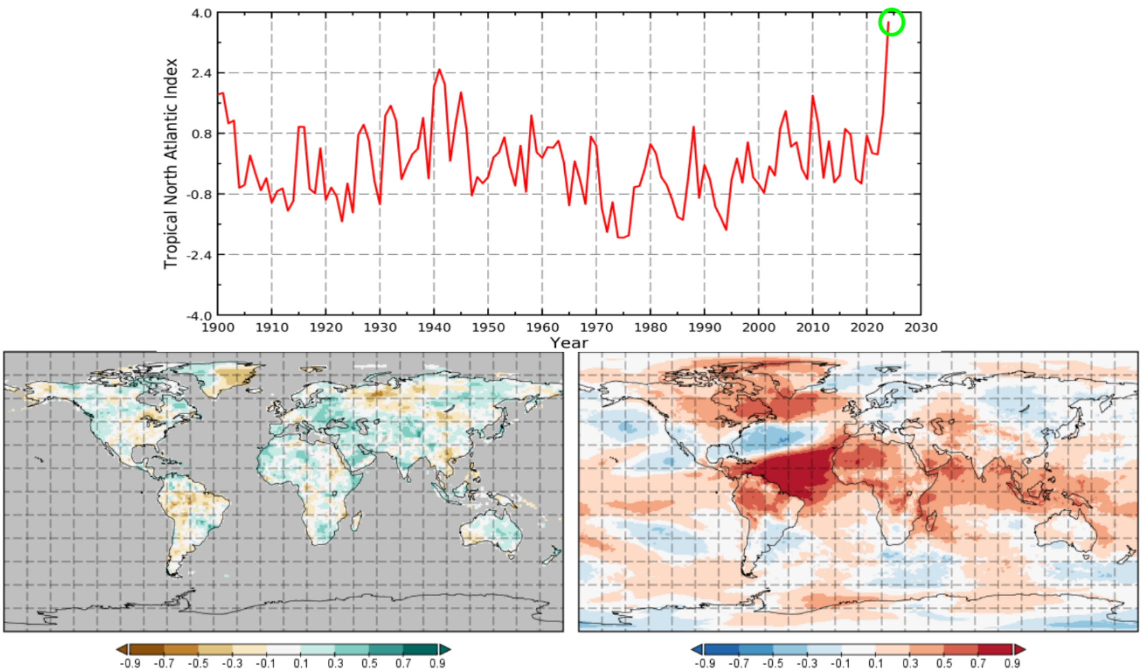

Figure 22: *Top panel: linearly detrended and standardized sea surface temperature average in the Tropical North Atlantic region since 1900 for the 12-month mean between August and the following July. Bottom panel, left: linear regression coefficient (1/K) of the July SPI12 and the TNA Index between 1981-2023. Bottom panel, right: linear regression coefficient (K/K) of the August to July near-surface temperature and the TNA Index between 1981-2023. The green circle highlights the value for August 2023 – July 2024. Sources: ERSSTv5 for sea surface temperature TNA Index, GPCC for precipitation and ERA5 for temperature.*

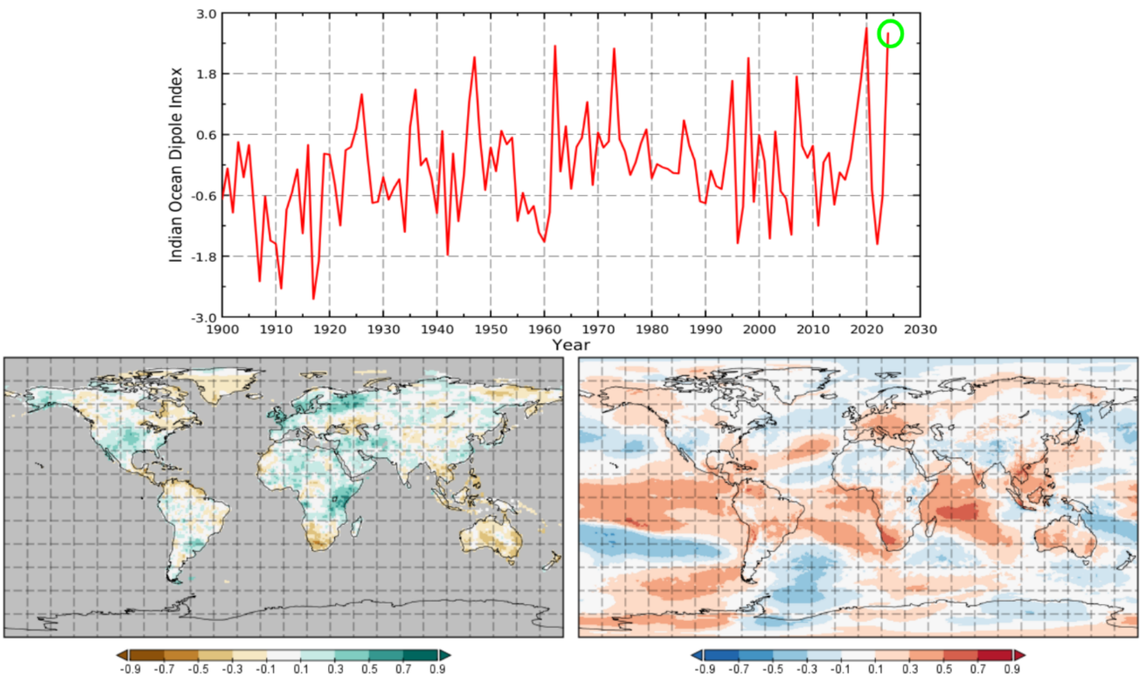

Figure 23: *Top panel: linearly detrended and standardized sea surface temperature of the IOD since 1900 for the 12-month mean between August and the following July. Bottom panel, left: linear regression coefficient (1/K) of the July SPI12 and the IOD Index between 1981-2023. Bottom panel, right: linear regression coefficient (K/K) of the August to July near-surface temperature and the IOD Index between 1981-2023. The green circle highlights the value for August 2023 – July 2024. Sources: ERSSTv5 for sea surface temperature IOD Index, GPCC for precipitation and ERA5 for temperature.*

Fire danger forecast

The wildfire hazard is a direct consequence of the elevated temperature anomalies and surface dryness, combined with the availability of fuel (i.e. dry litter and wood). The CEMS (Copernicus Emergency Management Service) Global Wildfire Information System (GWIS) provides mapping services of the fire danger forecast all over the world.[15] A moderate-to-very high danger is shown over western USA, most of Brazil, northern Argentina, most of the Mediterranean, southern and eastern Africa, eastern Europe, south-western Russia, central Asia, and most of Australia up to 5 September 2024 (Fig. 24).

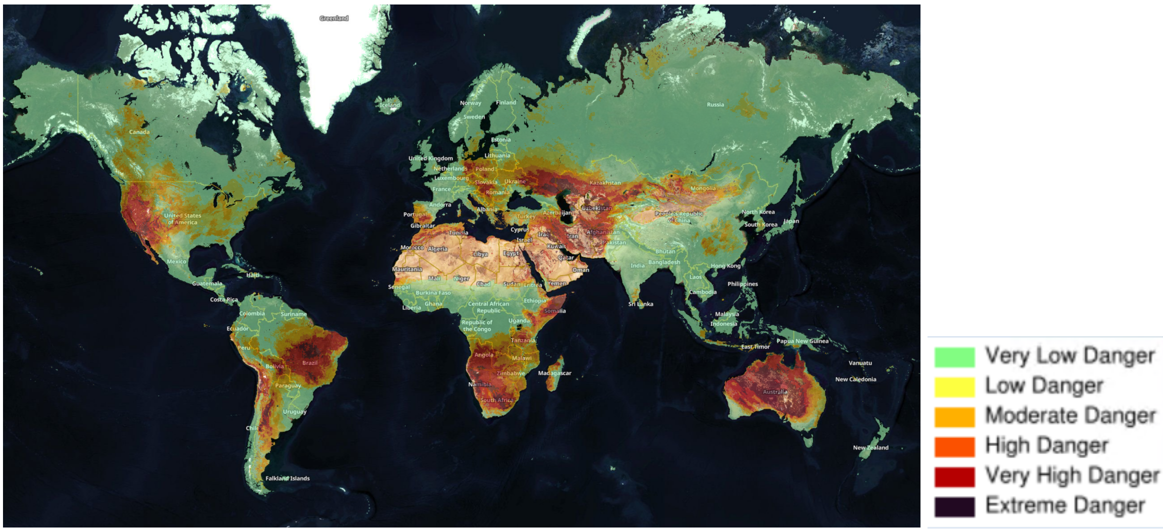

Figure 24: *Fire danger forecast expressed by the Fire Weather Index up to 5 September 2024. Data source: Global Wildfire Information System (GWIS)* [15].

Seasonal forecast

From September to November 2024, drier than average conditions (baseline 1981-2016) are predicted over most of South America, northern Mexico, the U.S., central-southern Canada, the Iberian Peninsula, eastern Europe, western and southern Africa, and central Asia. Wetter than average conditions are predicted over central Africa, northern Canada, central and northern Europe, most of Russia, India, south-east Asia, Indonesia, Australia, and Antarctica (Fig. 25).

According to the Copernicus C3S seasonal forecasts[16], warmer than usual conditions are likely to occur in the whole globe with almost no exception and the largest positive anomalies in Central America, South America, and most of Africa, up to December 2024. Precipitation forecasts (October - December 2024) are lower than average for the U.S., Mexico, South America, the Mediterranean, and central Asia; while wetter than normal

[15] https://gwis.jrc.ec.europa.eu/

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

conditions are predicted for Central America, Canada, northern Europe, Russia, India, south-east Asia and Oceania. Strong differences and great variability between models give a relevant uncertainty for precipitation seasonal forecast, in particular for Africa and Central-South America. Close monitoring is required to assess the severity and the extent of the impacts over the coming season.

The probability of occurrence of low river flows anomalies (compared with the seasonal discharge thresholds generated using the CEMS GloFAS seasonal reforecast[17]) from September to December 2024 is high in most of South America, some regions in central and southern Africa, and in Afghanistan and Pakistan. Medium-low probability is forecasted for the rest of South America, most of central-southern Africa, most of eastern Europe, western Russia, northern Mexico and the southern U.S., central-western Australia, and some regions in south-eastern Asia, as shown in Figure 26.[18] That figure shows the Seasonal Outlook - Basin Overview product: the map indicates the maximum probability of high flow or low flow anomaly, averaged for each major basin, and at any point in the forecast lead time.[19] The prolonged lack of precipitation, severe heatwaves, and warmer-than-average forecast are likely to reduce river flows further, with direct impacts on agriculture, ecosystems and energy production. Water resource management should be cautiously planned to limit impacts and identify adaptation strategies.

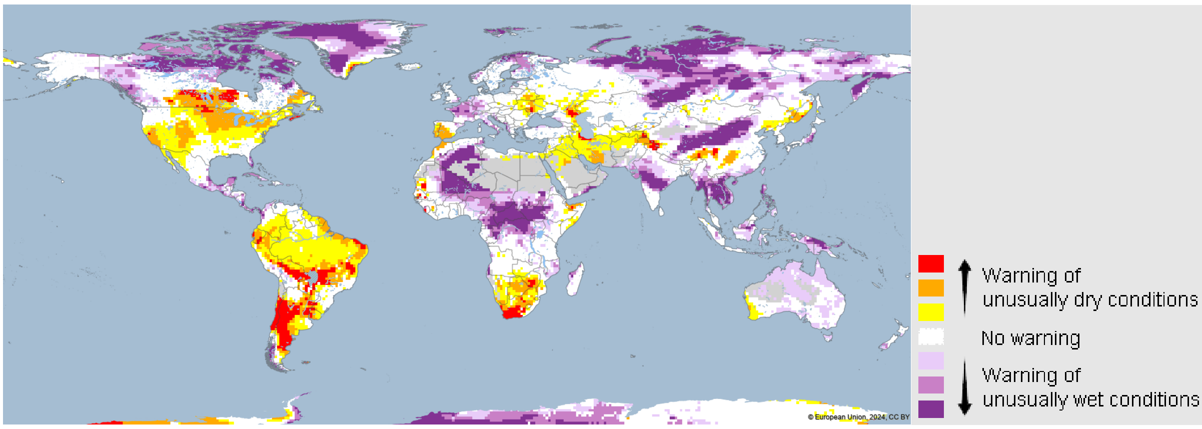

Figure 25: *Multi-system Indicator for Forecasting Unusually Wet and Dry Conditions, September-November 2024, based on dynamic forecasting systems from seven producing centers : ECMWF (European Centre for Medium-Range Weather Forecasts), CMCC (Centro Euro-Mediterraneo sui Cambiamenti Climatici), DWD (Deutscher Wetterdienst), ECCC (Environment and Climate Change Canada), Météo France, NCEP (USA National Centers for Environmental Prediction), UKMO (UK Meteorological Office).*[20]

[17] https://global-flood.emergency.copernicus.eu/technical-information/glofas-seasonal/

[18] The analysis is based on the CEMS GloFAS global implementation of open source LISFLOOD hydrological model outputs driven by 51 ensemble members of the ECMWF SEAS5 forecast. For more information: https://ec-jrc.github.io/lisflood/

[19] The Basin Overview gives a quick global overview, for more detailed information across the river network, and sub-basin differences, it is recommended to refer to the Seasonal Outlook - River Network and Seasonal Outlook - Reporting Points products.

[20] For more details on the Indicator for Forecasting Unusually Wet and Dry Conditions, and the other GDO and EDO indicators of drought-related information used in the report, see the Appendix at the end of the document.

Global Drought Overview - September 2024

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - GDO data up to 31/08/2024

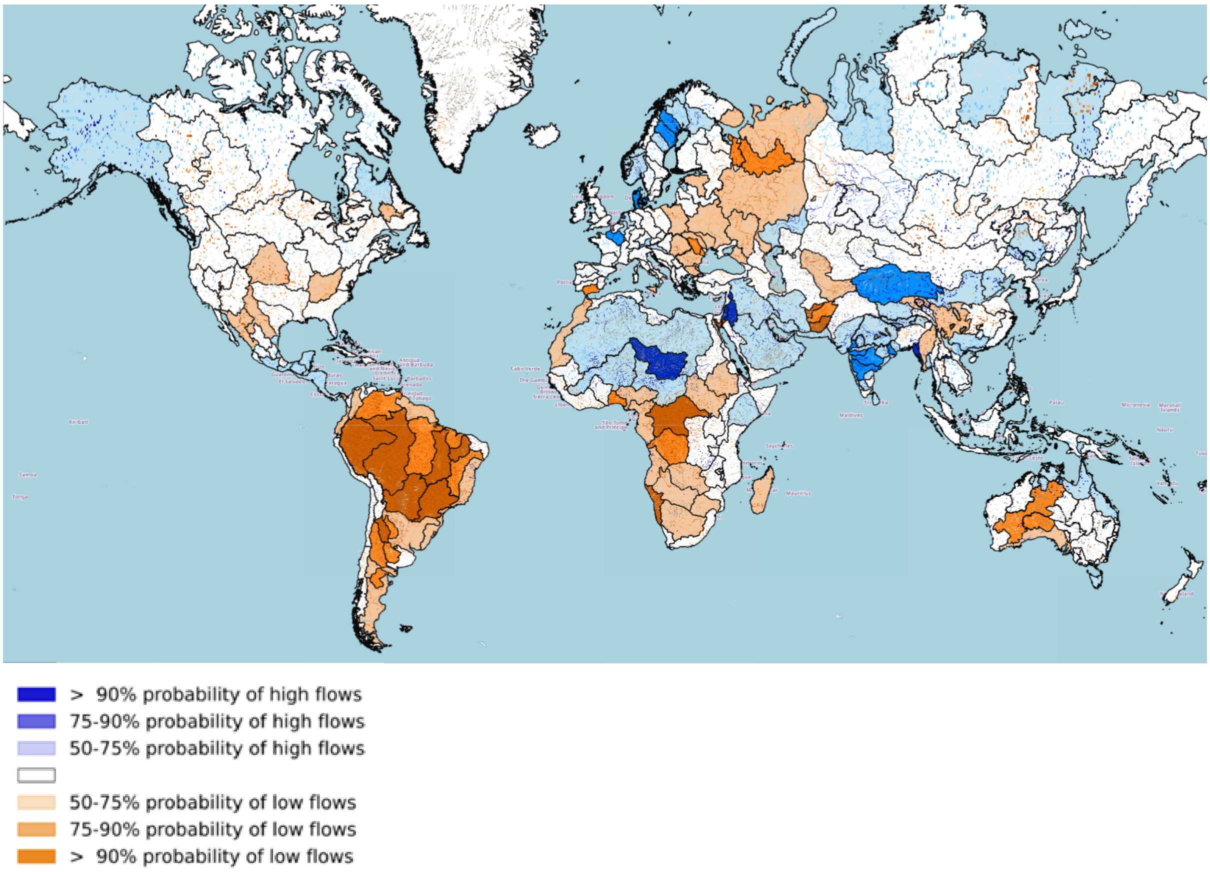

Figure 26: *Maximum probability [%] of high (> 80th percentile) or low (< 20th percentile) river flow, during the 4-month forecast horizon (September-December 2024) for basins and river network. Source: CEMS Global Flood Awareness System (GloFAS).*[21]

Reported impacts

According to the Integrated Food Security Phase Classification due to the crop damages and losses the Acute Food Insecurity ranges from stressed to crisis level (i.e. IPC Phase 2 and 3)[22] in most of the monitored countries (Africa, Central America, central and south-eastern Asia)[23].

According to GEOGLAM (Group on Earth Observations Global Agricultural Monitoring) Crop Monitor bulletins of September 2024[24] global crop conditions at the end of August show favourable prospects for maize, rice, and soybeans, while wheat is facing negative conditions. Yields for wheat are expected to be reduced in Canada, Europe, Russia, and Ukraine. Maize conditions are exceptional in most of the U.S., but there are areas of concern in Central America, Europe, southern Russia, Ukraine, and parts of Sub-Saharan Africa. Rice has generally favourable conditions except for minor areas in Asia, Central America, and West Africa. Soybeans also have favourable conditions except in parts of eastern Europe, Ukraine, and Russia. Drivers of the critical conditions

[21] https://global-flood.emergency.copernicus.eu/

[22] https://www.ipcinfo.org/ipcinfo-website/ipc-overview-and-classification-system/ipc-acute-food-insecurity-classification/

[23] https://www.ipcinfo.org/

[24] https://www.cropmonitor.org/

are summarized in Figure 27 and the regions where drought play a relevant role in reducing yield projection are central Canada, southern Mexico and Guatemala, south-eastern Brazil, northern Argentina, eastern Europe, south-western Russia, some regions in eastern Africa, and southern Australia.

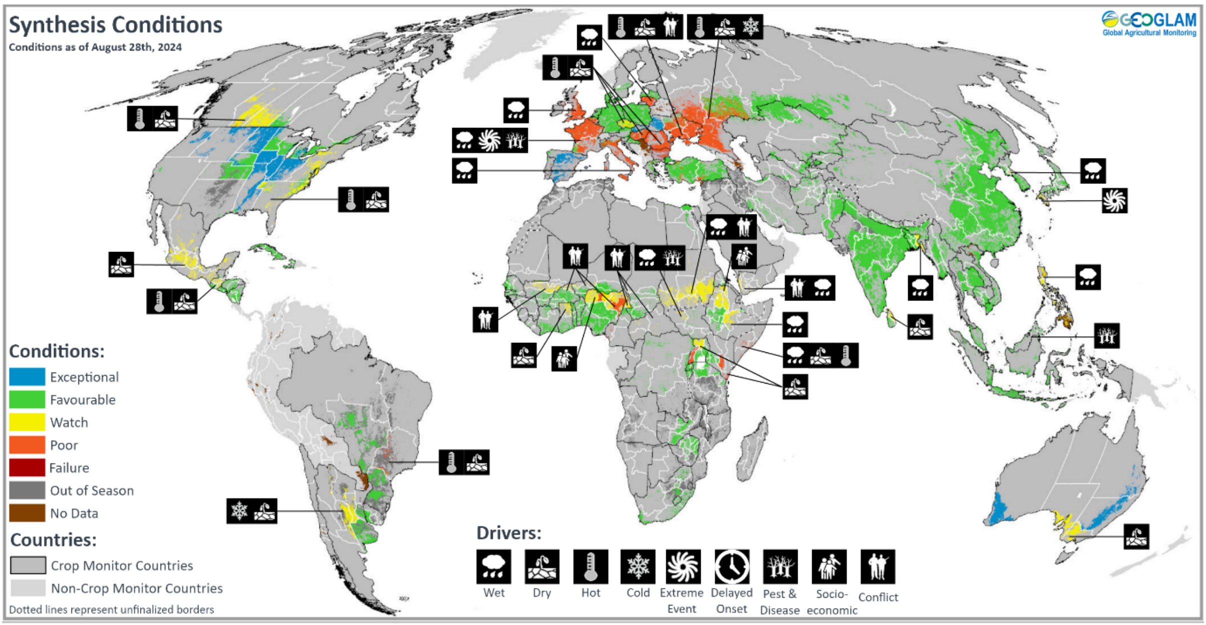

Figure 27: *Crop condition map as of August 28th 2024. Crop conditions over the main growing areas are based on a combination of inputs including remotely sensed data, ground observations, field reports, national, and regional experts. Crops that are in other than favourable conditions are labelled on the map with their driver. Source: GEOGLAM Crop Monitor, Licensed under CC BY 4.0.*[24]

In June and July 2024 (Fig. 28) conditions were significantly worse in southern Africa and particularly in the Zambezi basin (June 2024) and slightly worse in south-east Asia (July 2024). On the other side in eastern Europe and south-western Russia conditions were better and are now rapidly worsening. The other regions show more stable conditions.

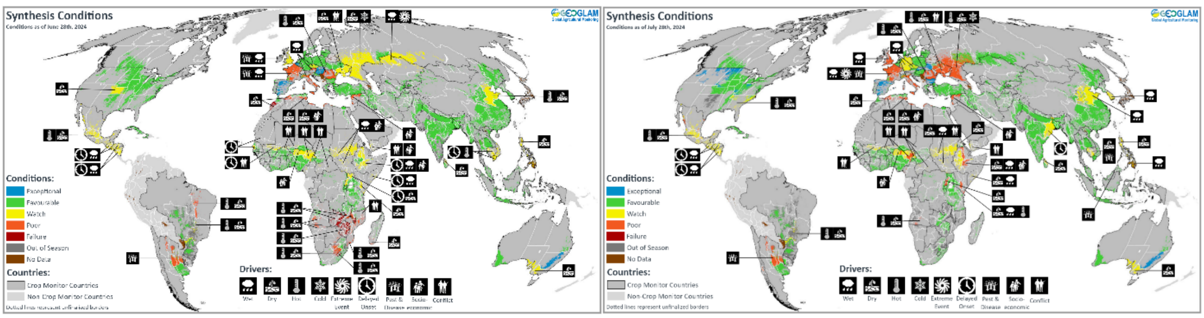

Figure 28: *Crop condition map as of June 28th (left) and July 28th (right) 2024. Crop conditions over the main growing areas are based on a combination of inputs including remotely sensed data, ground observations, field reports, national, and regional experts. Crops that are in other than favourable conditions are labelled on the map with their driver. Source: GEOGLAM Crop Monitor, Licensed under CC BY 4.0.* [24]

The Famine Early Warning Systems Network (FEWS NET) reports that over 30 million people in Southern Africa will require food aid between October 2024 and March 2025 due to the impact of the El Niño-induced drought. The food aid demand is expected to reach historic levels, with the highest concerns in Zimbabwe, southern Malawi, southern and central Mozambique, and southern Angola. El Niño led to significantly below-normal harvests, causing maize prices to rise further and putting more strain on people's ability to secure food. The organization urges governments, donors, humanitarian partners, and other stakeholders to mobilize and respond to the high food aid needs from now until early 2025. Conflict in the eastern Democratic Republic of the Congo and Cabo Delgado, Mozambique, also exacerbates the situation by affecting agricultural production and people's income.[25] Lesotho is also experiencing food insecurity: after declaring in July 2024 a state of National Food Insecurity Disaster after a historic drought triggered by El Niño, the government was granted in September of US$2-million aid from the United Nations Central Emergency Response Fund (UN CERF) to respond to the humanitarian crisis[26].

CEMADEN (Centro de Monitoramento e Alertas de Desastres Naturais, the Brazilian Natural Disaster Monitoring and Alert Center) has released a comprehensive drought situational assessment of the Brazilian territory on September 2024[27]. The report indicates that many municipalities have faced drought conditions for 12 consecutive months, which has significantly reduced river levels and increased the risk of fire spreading. Many regions in Brazil have faced considerable amount of consecutive days without rain: the Central-West, part of the Southeast and Northeast regions are the most affected by the water deficit, with more than 100 consecutive days without precipitation, especially in Goiás and parts of the states of Mato Grosso, Minas Gerais and Bahia. Municipalities in the state of Minas Gerais such as Verdelândia, Nova Porteirinha, Pai Pedro, Janaúba, Catuti and Capitão Enéas, as well as others in the surrounding area, have already accumulated around 150 days without rain. The report highlights that, in addition to its intensity, the current drought is already one of the longest in recent decades.

INPA (Instituto Nacional de Pesquisas da Amazônia, the Brazilian National Institute for Amazon Research) indicates that forest fires have been a source of concern in the Amazon region in 2023 and 2024[28], resulting in higher than usual concentrations of particulate matter and pollution in the atmosphere. Indeed, monitoring stations in the area have recorded extremely high carbon monoxide levels of about 3,000 ppb (parts per billion) in late 2023 (for reference, in the months of April and May, which are part of the rainy season, the number varies between 80 and 100 ppb). The increase in fires in the Amazon region combined with wind dynamics favoured the arrival of smoke plumes to far reaching places in the country, including major cities in the South and Southeast regions of Brazil.

South America's major rivers are facing unprecedented low water levels due to severe droughts episodes in the continent, disrupting shipping and agriculture, particularly in the Amazon and Paraná river basins. The Paraguay River has seen a record low level while the Parana River in Argentina is also near to year-lows, impacting grain shipments, fishing, and navigation in countries such as Bolivia, Paraguay, Argentina, and Brazil[29]. Paraguay's fishing union estimates that the decline in water levels has put 1,600 fishermen out of work. The Amazon and one of its main tributaries, the Madeira River, have also registered new daily record lows[30].

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[25] https://fews.net/southern-africa-face-historically-high-food-assistance-needs-2025

[26] https://www.unocha.org/publications/report/lesotho/lesotho-receives-un-support-people-affected-drought

[27] https://www.gov.br/cemaden/pt-br/assuntos/monitoramento/monitoramento-de-seca-para-o-brasil/monitoramento-de-secas-e-impactos-no-brasil-agosto-2024/NOTATECNICAN529202SEICEMADENSECAS.pdf

[28] https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2024/09/queimadas-aumentam-em-ate-80-vezes-a-concentracao-de-poluentes-na-atmosfera-da-amazonia

[29] https://apnews.com/article/paraguay-river-drought-amazon-fires-climate-change-deforestation-shortage-ce7bb22855f6ed9af43381aa246c7d30

[30] https://www.reuters.com/world/americas/brazils-amazon-drought-disrupts-residents-lives-2024-09-15/

The Brazilian president Lula da Silva announced in September 2024 the plan to create a National Climate Authority, with the aim to deal with extreme natural phenomena[31].

In March 2024, the Government of South Sudan closed all schools in Juba (the capital of South Sudan) and some parts of the country for two weeks (March 18 – April 3), due to the extreme heat, with temperatures ranging between 41 and 45 degrees Celsius. On 15 March, the National Ministry of health reported the death of at least 15 children due to meningitis and exposure to heatwaves.[32]

Drought is affecting south-eastern Europe, with the hottest summer ever registered in the Balkans, where drought was combined with four heatwaves. Several impacts were registered: river low flows, soil drying up, crop damages, fresh water rationing, power cuts due to poor hydropower basins and triggered forest fires.[33]

[31] https://en.mercopress.com/2024/09/11/brazil-lula-announces-creation-of-national-climate-authority

[32] Sources: https://data.unhcr.org/en/documents/details/107564; https://www.africanews.com/2024/03/28/south-sudan-schools-to-reopen-from-april-2nd-as-heatwave-subsides/; https://www.theeastafrican.co.ke/tea/science-health/african-countries-facing-unprecedented-high-temperatures-4565902; https://earthobservatory.nasa.gov/images/152600/heat-wave-in-east-africa; https://www.afro.who.int/sites/default/files/2024-03/AIRA%20Infodemic%20Trends%20Report%2011-18%20March%202024_1.pdf

[33] https://es.euronews.com/green/2024/09/10/tres-semanas-sin-una-gota-de-lluvia-los-balcanes-sufren-el-peor-verano-de-los-ultimos-130-

Appendix: GDO and EDO indicators of drought-related information

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 (or even 24-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** 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. Negative fAPAR anomalies with respect to the long-term average are associated with negative impacts on vegetation.

The **Multi-system 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 seven components: ECMWF (European Centre for Medium-Range Weather Forecasts), CMCC (Centro Euro-Mediterraneo sui Cambiamenti Climatici), DWD (Deutscher Wetterdienst), ECCC (Environment and Climate Change Canada), Météo France, NCEP (USA National Centers for Environmental Prediction), UKMO (UK Meteorological Office).

Check https://drought.emergency.copernicus.eu/factsheets for more details on the indicators.

Glossary of terms and acronyms

C3S	Copernicus Climate Change Service
CEMADEN	Centro de Monitoramento e Alertas de Desastres Naturais
CEMS	Copernicus Emergency Management Service
CERF	Central Emergency Response Fund
CMCC	Centro Euro-Mediterraneo sui Cambiamenti Climatici
DWD	Deutscher Wetterdienst
EDO	European Drought Observatory of CEMS
EC	European Commission
ECCC	Environment and Climate Change Canada
ECMWF	European Centre for Medium-Range Weather Forecasts
ENSO	El Niño Southern Oscillation
ERA5	ECMWF Reanalysis v5
ERCC	European Emergency Response Coordination Centre
ESA	European Space Agency
fAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FEWS NET	Famine Early Warning Systems Network
GDO	Global Drought Observatory of CEMS
GEOGLAM	Group on Earth Observations Global Agricultural Monitoring
GloFAS	Global Flood Awareness System of CEMS
GRACE	Gravity Recovery and Climate Experiment
GWIS	Global Wildfire Information System
INPA	Instituto Nacional de Pesquisas da Amazônia
IOD	Indian Ocean Dipole
IPC	Integrated Food Security Phase Classification
JMA	Japan Meteorological Agency
JRC	Joint Research Centre

KNMI	Koninklijk Nederlands Meteorologisch Instituut
NCEP	USA National Centers for Environmental Prediction
ppb	parts per billion
SEAS5	Seasonal Forecasting System 5
SMA	Soil Moisture Anomaly
SPI	Standardized Precipitation Index
TNA	Tropical North Atlantic
TWS	Total Water Storage
UK	United Kingdom of Great Britain and Northern Ireland
UKMO	UK Meteorological Office
UN	United Nations
USA	United States of America
VIIRS	Visible Infrared Imaging Radiometer Suite

Global Drought Overview - September 2024
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GDO and EDO indicators versioning

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

GDO, EDO indicator	Version
▪ Ensemble Soil Moisture Anomaly (SMA)	*v.3.0.1*
▪ Fraction of Absorbed Photosynthetically Active Radiation (fAPAR) Anomaly (VIIRS, Visible Infrared Imaging Radiometer Suite)	*v.3.0.0*
▪ GRACE-derived Total Water Storage (TWS) Anomaly	*v.2.0.0*
▪ Multi-System Indicator for Forecasting Unusually Wet and Dry Conditions	*v .1.2.0*
▪ Standardized Precipitation Index (SPI, ERA5)	*2.1.0.0*

Check https://drought.emergency.copernicus.eu/download for more details on indicator versions.

Distribution

For use by the ERCC and related partners, and publicly available for download at GDO website: https://drought.emergency.copernicus.eu/reports

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