

GDO Analytical Report

Drought in centre-south Brazil – June 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 22/06/2021



Table of Contents

Executive summary	1
Risk of drought impact for agriculture (RDri-Agri).....	2
Precipitation	3
Standardized Precipitation Index (SPI)	5
SPI outlook	7
Soil moisture and groundwater anomaly.....	8
fAPAR anomaly	10
CEMADEN's Integrated Drought Index (IDI)	12
Reported impacts.....	13

Executive summary

- Drought is affecting central-southern Brazil (including the states of Minas Gerais, São Paulo, Paraná, Mato Grosso do Sul) and parts of Paraguay and Bolivia, an area roughly corresponding geographically to the Paraná basin. With shrinking reservoirs, hydropower production is at risk, with potential cascading effects on the whole economy of these countries. Crop damages have been reported from Brazil and more impacts on the primary sector are expected in the coming months. Ecosystems, including those of Pantanal (the largest tropical wetlands area in the world), are also affected. Brazilian authorities have declared drought emergency for the Paraná Basin until November 2021.
- A lack of precipitation during most of 2021, combined with the marked deficit accumulated during 2020, has led to the current dry conditions, as reflected both by groundwater levels and soil moisture. Some locations (e.g. eastern São Paulo state) received nearly half of the expected rainfall during this period. Deforestation of the Amazon, global warming, and La Niña, in addition to natural inter-annual variability, are considered to be the main drivers of the increasing incidence of drought that has affected the region in recent years.
- The six-month precipitation outlook leans towards normal conditions and, despite uncertainty, suggests no meaningful recovery for at least the trimester up to August 2021. Depending on the amount of precipitation in the last quarter of 2021, the next growing season might be affected. Concerning surface water and groundwater supplies, these may well evince below average conditions, due to the long-term deficits accumulated in 2020 and 2021.

Risk of drought impact for agriculture (RDri-Agri)

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

Regarding precipitation, 2020 was a difficult year for large parts of South America, with unrelenting deficits spread over vast areas, notably across the whole La Plata / Paraná Basin (north-east Argentina, Paraguay, eastern Bolivia, Uruguay, southern Brazil; Figure 1, right). During the following months conditions improved in some places, but not in Brazil. Despite flooding in the Amazon basin and in the northern Brazil¹, 2021 brought dry conditions in the centre-south of the country, within the Paraná basin in particular and especially the upper Paraná. Moderate risks of impact loom primarily over the states of Minas Gerais, São Paulo, Paraná, Mato Grosso do Sul (Figure 1, left. For reference to Brazilian states see Figure 14). Neighbouring regions, including fringes of Paraguay, Argentina and Bolivia, are also affected. Overall, about 15-20 million people are exposed to moderate to high risks of drought impacts. Though it has fluctuated, some level of risk has been constantly present in the area for many months, as illustrated by the time-series data shown in Figure 2.

Agriculture is an important sector of Brazilian economy, and the centre-south of the country is a key area for agricultural production, particularly for grains, oilseeds, and cattle. Brazil is a major global producer of soybeans, maize, sugar and coffee, to the extent that the country annual yields influence global prices. In the centre-south, thanks to modern agriculture and a good coping capacity, food security is not a concern and population vulnerability is relatively low, although poverty is still common.

Ecosystems are also seriously threatened by drought. The Pantanal region, an area of utmost importance for global biodiversity and home to several Ramsar sites², is currently affected, with its ecosystems exposed following the marked drought of 2020^{3, 4, 5}.

Limited precipitation in the upper Paraná Basin may determine hydrological drought conditions hundreds of kilometres to the south, where rivers are a key resource for the local and national economies of Paraguay and Argentina. Indeed, both countries are strongly dependent on waterborne inland transportation and hydropower. Paraguay's power generation is 100% hydroelectric⁵, and Brazil also relies on hydropower for two thirds of its needs. During the second

¹ https://erccportal.jrc.ec.europa.eu/ERCmaps/ECDM_20210611_South-America_Floods.pdf

² Convention on Wetlands <https://www.ramsar.org/sites-countries/wetlands-of-international-importance>

³ https://edo.jrc.ec.europa.eu/documents/news/GDODroughtNews202004_Great_Chaco_and_Paraguay_basin.pdf

⁴ <https://phys.org/news/2021-05-extreme-drought-affected-pantanal.html>

⁵ <https://www.hydropower.org/country-profiles/paraguay>

GDO Analytical Report

Drought in centre-south Brazil – June 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 22/06/2021



half of 2020, relevant impacts were recorded to the aforementioned sectors and, given current conditions, they are likely to continue towards the end of 2021⁶.

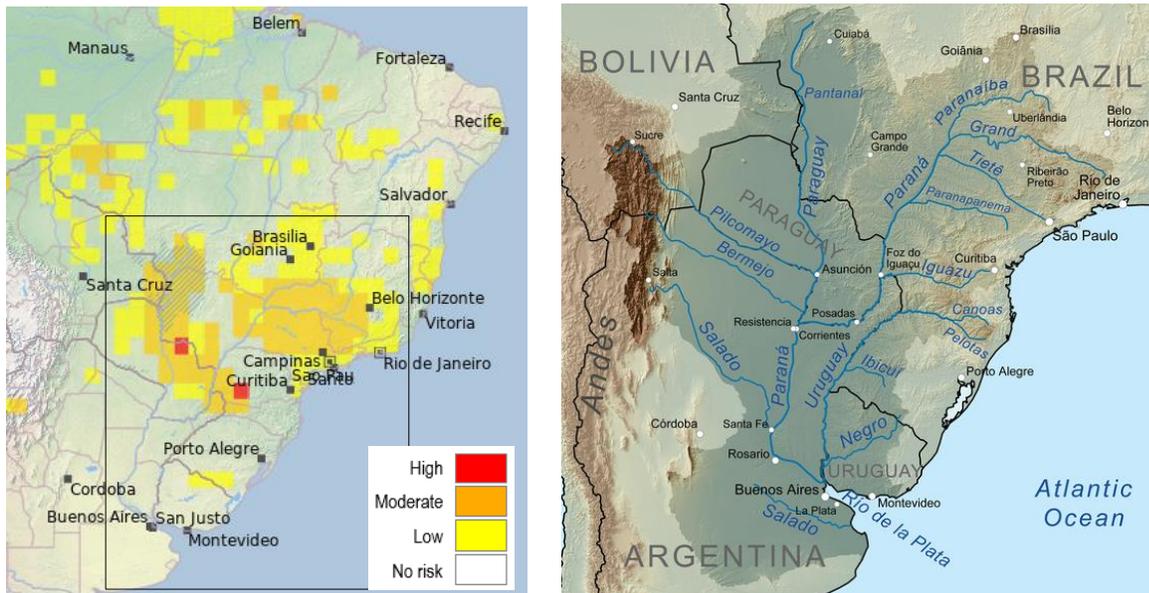


Figure 1: Left: risk of drought impact for agriculture (RDri-Agri), 1 to 10 June 2021; the box outlines the La Plata basin. Right: La Plata Basin (credits: Kmusser, CC BY-SA 3.0, Wikimedia C.).

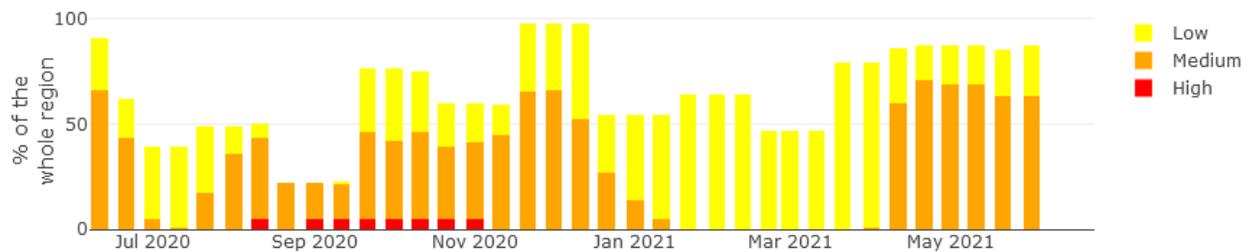


Figure 2: Risk of drought impact (RDri-Agri), evolution over time in São Paulo state (Brazil).

Precipitation

Precipitation is measured by total monthly levels of rainfall, as shown in Figure 3. Precipitation patterns are radically different between the upper Paraná Basin (and inner regions northwards) and the lower area of the basin. The upper area, currently at the core of the drought, has a marked inter-seasonal variation, with a brief dry season and a peak around December and

⁶ Chapter 4.5
https://publications.jrc.ec.europa.eu/repository/bitstream/JRC125320/jrc125320_annual_droughts_report_final.pdf

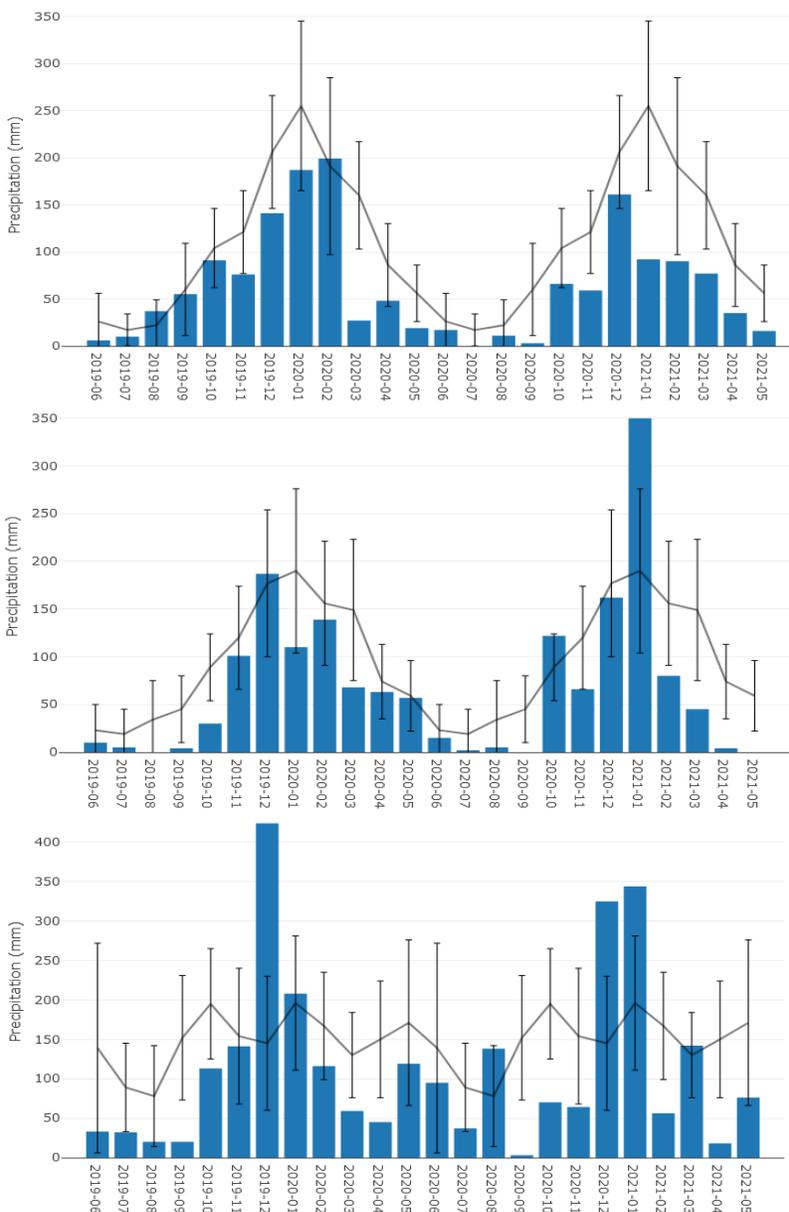
GDO Analytical Report

Drought in centre-south Brazil – June 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 22/06/2021



January (Figure 3, top and centre). Seasonality of rainfall fades away mid-basin, over the cross-boundary area of Paraguay, Brazil and Argentina (Figure 3, bottom). Nevertheless, strong deficits were recorded in both parts of the basin, and many months show half or less the long-term average. In several areas, the accumulated deficit during the whole of 2020 and the first half of 2021 is remarkable, as displayed by Figure 4, reaching a mere 50% of the long-term average expected for the same period.



North-west of São Paulo state, near Pontalinda, -20.4 N, -50.6 E

North-west of Mato Grosso do Sul, -19.1 N, -56.1 E

West Paraná, -24.2 N, -53.0 E

Figure 3: Monthly total precipitation (blue bars) in three selected locations, with the long-term monthly average and standard deviation (1981-2010).

The severe droughts of the past ten years over the wider Paraná Basin can be linked to a variety of drivers, beyond the inter-annual natural fluctuations of rainfall. Deforestation of the Amazon may cause a reduction of cloud formation and rainfall southwards⁷. Global warming could increase loss of humidity⁸. Especially in relation to the current drought, La Niña may also play a key role⁹.

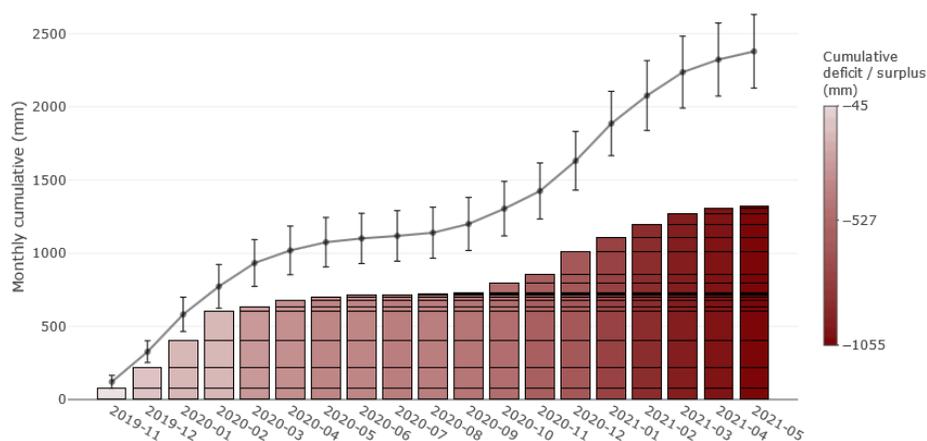


Figure 4: Cumulative precipitation over a period of 18 months near Pontalinda (São Paulo, Brazil, -20.4 N, -50.6 E). The bar colors indicate the cumulative deficit (red gradient) or surplus (blue gradient), compared to the cumulated monthly long-term average (solid line), for the same time span and location. The boxes overlapping the bars are the monthly totals stacked.

Standardized Precipitation Index (SPI)

The GDO indicator SPI is used to monitor the occurrence of meteorological drought. The lower (i.e. more negative) the SPI, the more intense is the drought.

Very low values in the mid- and long-term SPIs are observed over an enormous area spanning across central and southern Brazil, indicating a very severe meteorological drought (Figure 5). The similarity between the anomaly distributions at the 9- and 24-month time-scale suggests how both the last wettest months and those of 2019/2020 brought much less rainfall than normal, and roughly over the same geographical regions. In the shorter term, only some locations seem to experience strong deficit (Figure 5, bottom), but still among those hardest hit previously (Pantanal in Mato Grosso do Sul and the east, western São Paulo, southern Minas

⁷ <https://www.frontiersin.org/articles/10.3389/frwa.2021.639204/full>

⁸ <https://www.scielo.br/j/brag/a/YJWkkMVrfYKbgJmbTrBynbL/>

⁹ <http://www.cnpt.embrapa.br/pesquisa/agromet/pdf/applications/cap11.pdf>

GDO Analytical Report

Drought in centre-south Brazil – June 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 22/06/2021



Gerais, parts of Paraná). Looking at the extent and values of SPI-24 in particular, this drought event is likely to have influence on soil conditions and water availability in general, for quite a long time. Indeed, as the time-series of Figure 6 show, the current prolonged lack of precipitation is the severest on record since at least 1970 at different time scales and locations.

According to Brazil's Centre for Monitoring and Early Warning of Natural Disasters (CEMADEN¹⁰), "drought duration, measured by continuous SPI values, is longer than six months mostly over Central Brazil and the northwest part of São Paulo state".

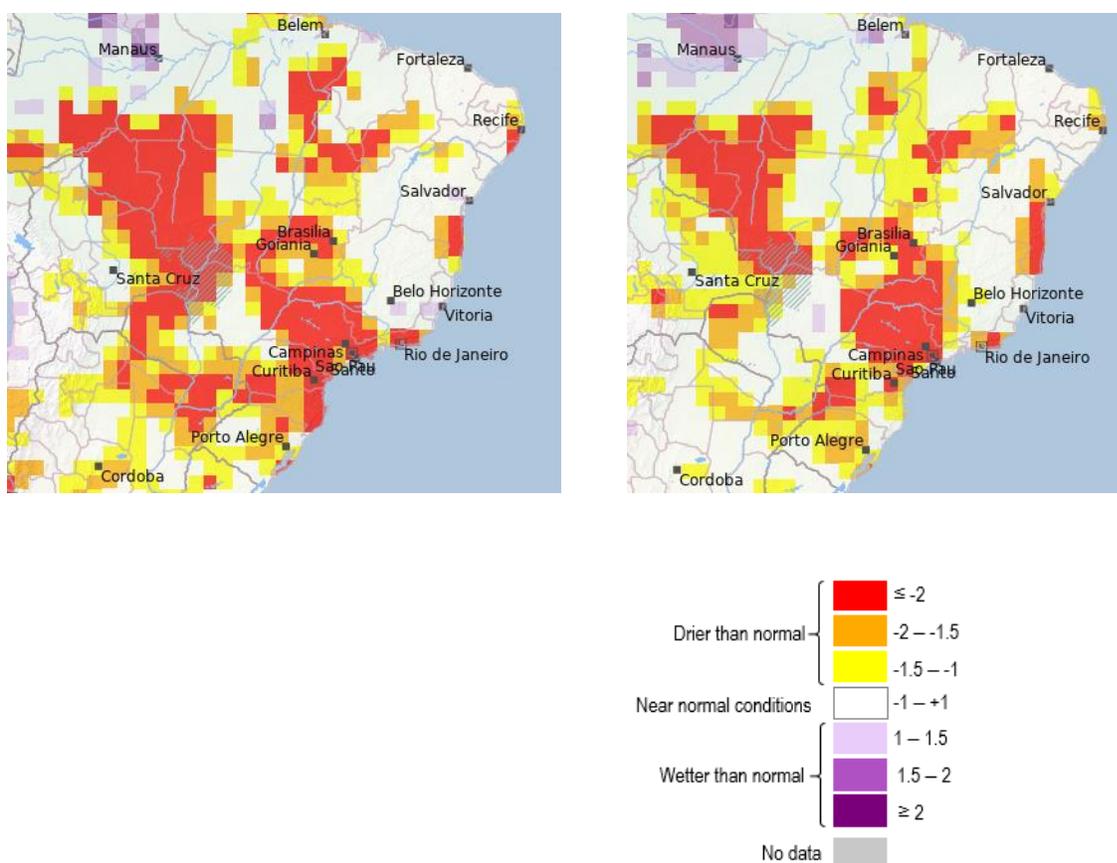


Figure 5: SPI for May 2021, at cumulative periods of 24 months (top-left), 9 months (top-right), 3 months (bottom-right).

¹⁰ Contributed by Dr. Marcelo Zeri, Dr. Ana Paula Martins do Amaral Cunha, Dr. Luz Adriana Cuartas, Dr. José A. Marengo

GDO Analytical Report

Drought in centre-south Brazil – June 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 22/06/2021

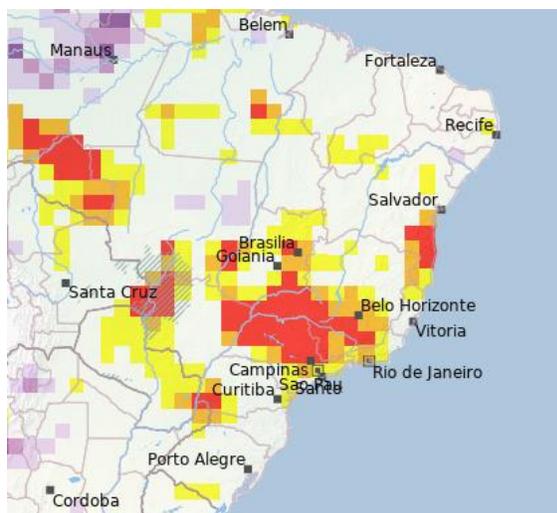
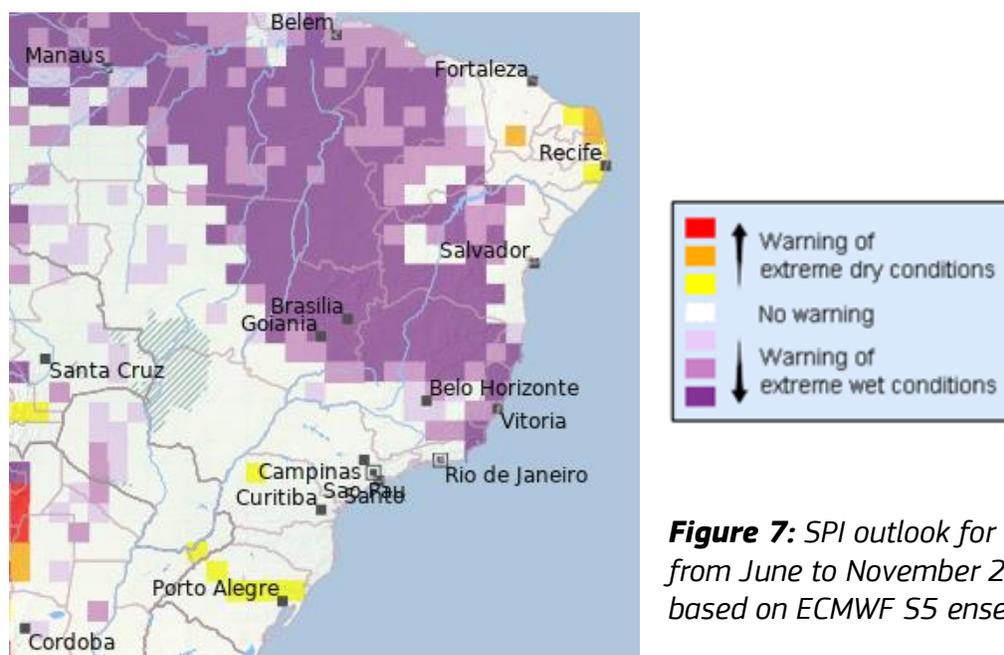


Figure 6: Time-series of SPI for two selected locations: western São Paulo (SPI-12, top), and Pantanal (Mato Grosso do Sul, SPI-48, bottom).

SPI outlook

In June 2021, the region is at the start of its driest period of the year- more so especially far from the coast and north of Paraguay - with no chance to recover from the accumulated deficits.

Therefore, the neutral outlook for the trimester from June to August is of limited relevance (not shown). At the six-month time-scale, uncertainty is still high, and mostly neutral conditions are forecasted up to November 2021, over the areas currently experiencing drought (Figure 7). Some improvement may happen in the states of Paraná (south) and Santa Catarina, where rainfall is more evenly distributed during the year and more abundant overall. Higher than average precipitation is expected to the north-east, but any extra rainfall there would not bring relief, since all receiving rivers drain northwards and away from the affected basins (Paraná).



Soil moisture and groundwater anomaly

The aim of the GDO soil moisture indicator is to provide an assessment of the topsoil water content, which is a direct measure of drought conditions, specifically the difficulty for plants to extract water from the soil.

At the end of 2020, soil moisture conditions were very poor across most of southern Brazil and beyond to Argentina, as well as eastern Paraguay and the Bolivian lowlands (Figure 8, top-left). By January 2021, all soil moisture deficits appeared to have been compensated and even surpluses are indicated in some of the same areas, thanks to abundant precipitation recorded around this time (Figure 8, top-right). However, as soon as precipitation decreased again during all of the following months, moisture deficits returned, especially in states of São Paulo, Minas Gerais and Mato Grosso do Sul (Figure 8, bottom-left). The trend of the anomalies is well captured by the time-series from São Paulo state (Figure 9).

GDO Analytical Report

Drought in centre-south Brazil – June 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 22/06/2021



A further constraint on water availability is the depletion of groundwater, as captured by the total water storage anomalies. As of March 2021, a groundwater negative anomaly was detected over a wide belt just north of Paraguay, spanning from eastern Bolivia to the Atlantic coast, including the Brazilian Pantanal (Figure 10). The whole area has been constantly affected by relatively low groundwater levels since May 2020, as shown by reduced levels in rivers and wetlands, without providing any buffering against short-term fluctuations in precipitation for water abstraction.

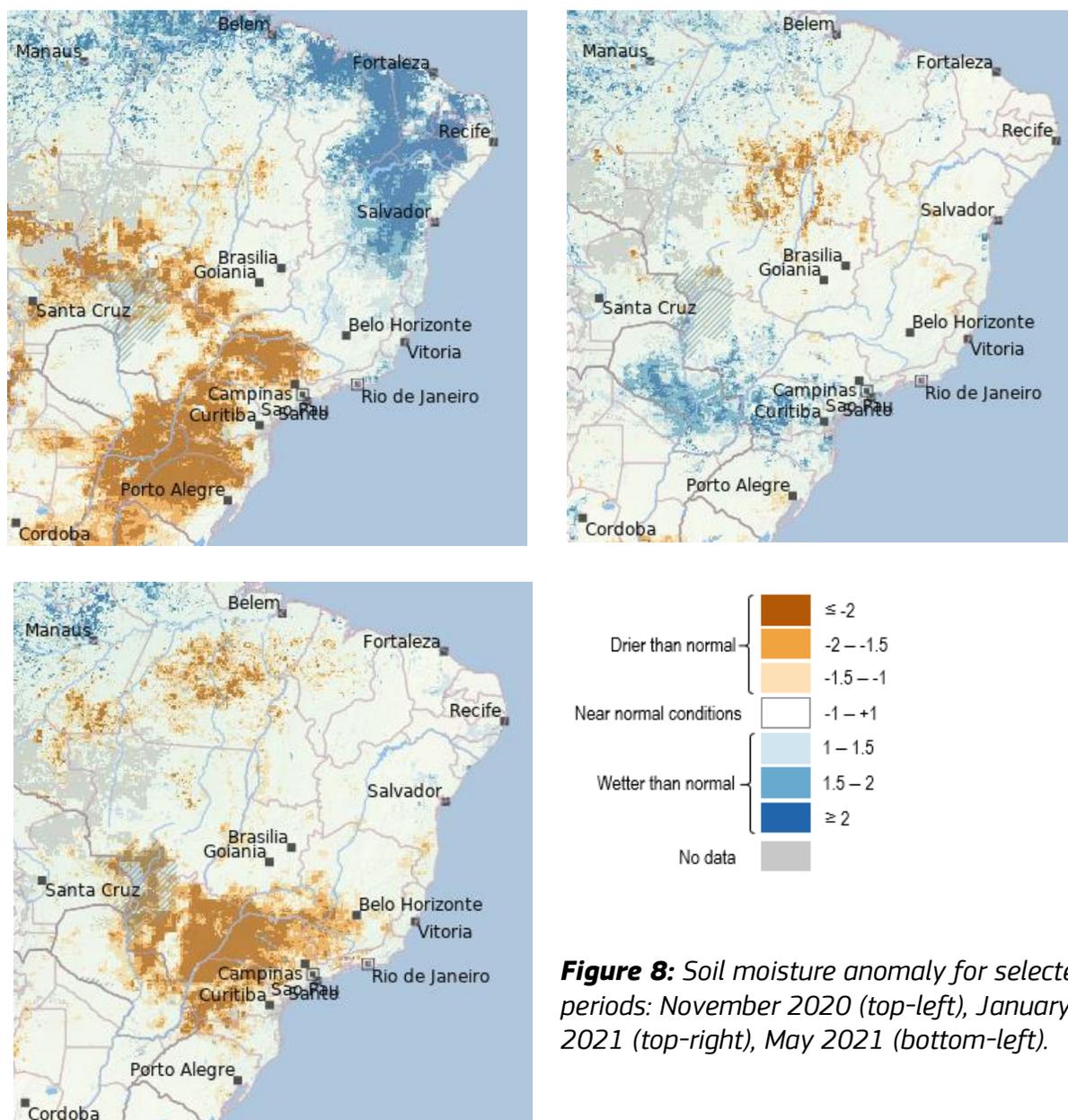


Figure 8: Soil moisture anomaly for selected periods: November 2020 (top-left), January 2021 (top-right), May 2021 (bottom-left).

GDO Analytical Report

Drought in centre-south Brazil – June 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 22/06/2021

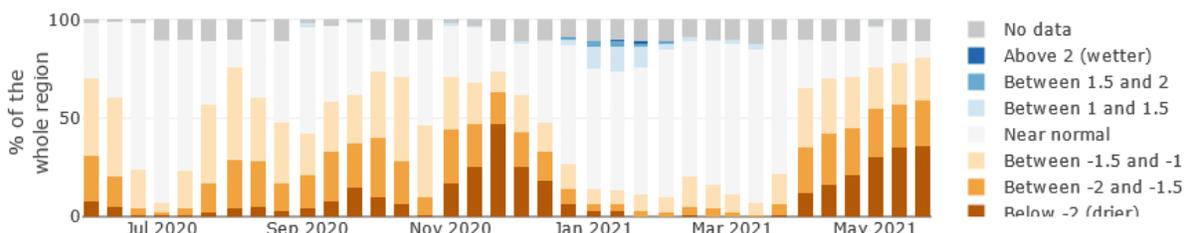


Figure 9: Soil moisture anomaly, evolution over time in state of São Paulo (Brazil).

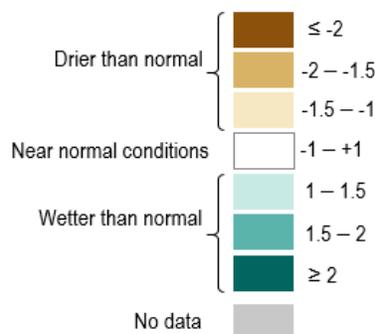


Figure 10: Gravity Recovery and Climate Experiment (GRACE) Total Water Storage (TWS) Anomaly over Brazil, March 2021.

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 impacts on vegetation.

In line with soil moisture, widespread fAPAR negative anomalies were detected across the centre-south of Brazil at the end of 2020 (figure 11, top-left). Conditions improved in the first quarter of 2021 in some areas, at the core of the growing season, and decreased again since

GDO Analytical Report

Drought in centre-south Brazil – June 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 22/06/2021



April 2021 (figure 11, top-right and bottom-left respectively). Such oscillations reflect quite well the same trends observed for soil moisture and groundwater anomalies in the upper Paraná basin. However, in the Pantanal area (Mato Grosso do Sul) and eastern Paraguay, positive conditions persist overall, and may indicate a higher resilience of vegetation.

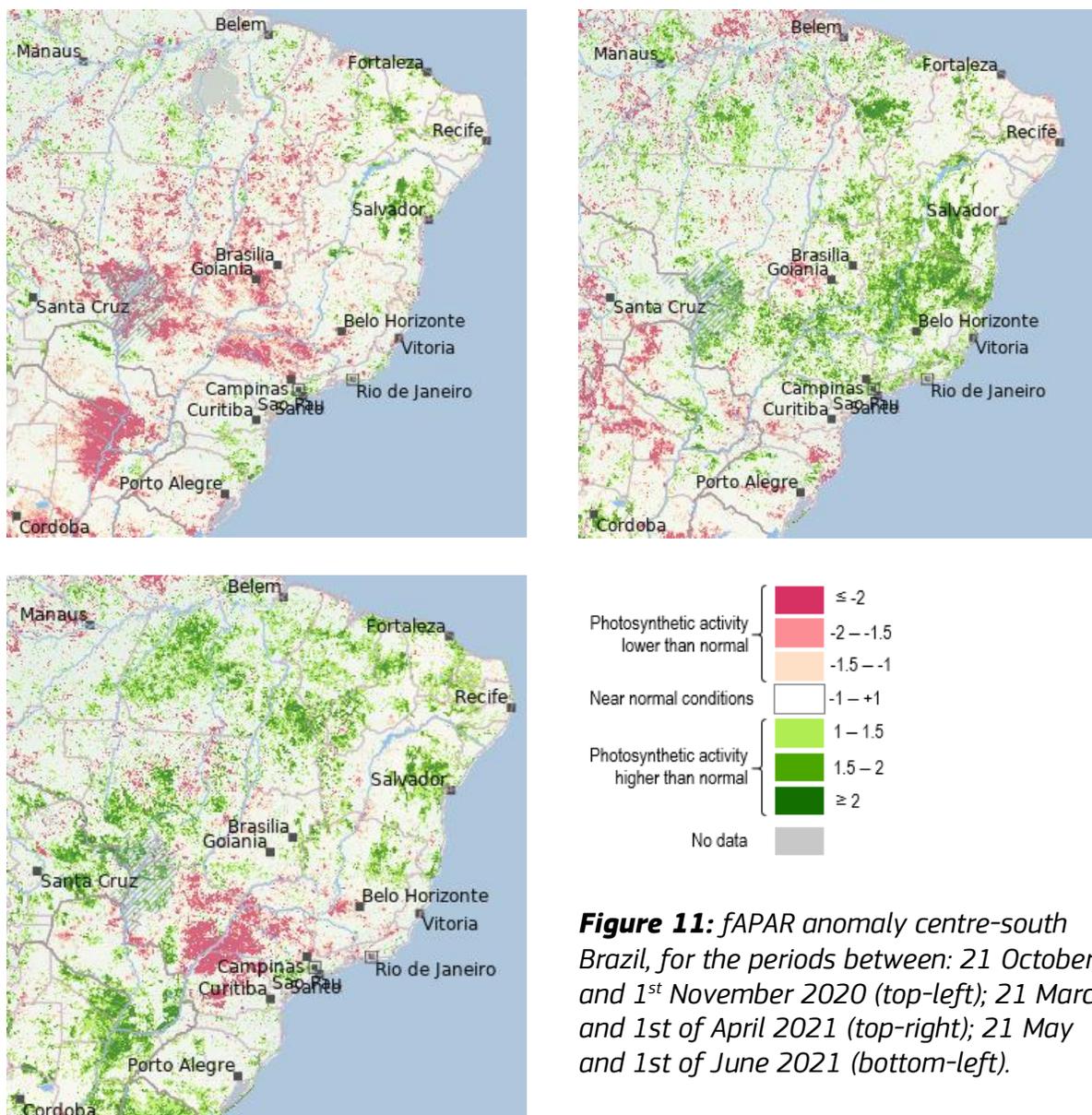


Figure 11: fAPAR anomaly centre-south Brazil, for the periods between: 21 October and 1st November 2020 (top-left); 21 March and 1st of April 2021 (top-right); 21 May and 1st of June 2021 (bottom-left).

CEMADEN's Integrated Drought Index (IDI)¹¹

The analysis of the GDO drought indicators, outlined previously, leads to similar conclusions as the results of the Integrated Drought Index (IDI), calculated by Brazil's Centre for Monitoring and Early Warning of Natural Disasters (CEMADEN). The IDI indicator is calculated as an average of the Standardized Precipitation Index (SPI, 3- and 6-months scales), and the satellite products Vegetation Health Index (VHI, by NOAA), and Relative Extractable Water (REW), from NASA Soil Moisture Active Passive satellite (SMAP). The indices are converted to five different classes of drought intensity and one class of normal conditions (Figure 12).

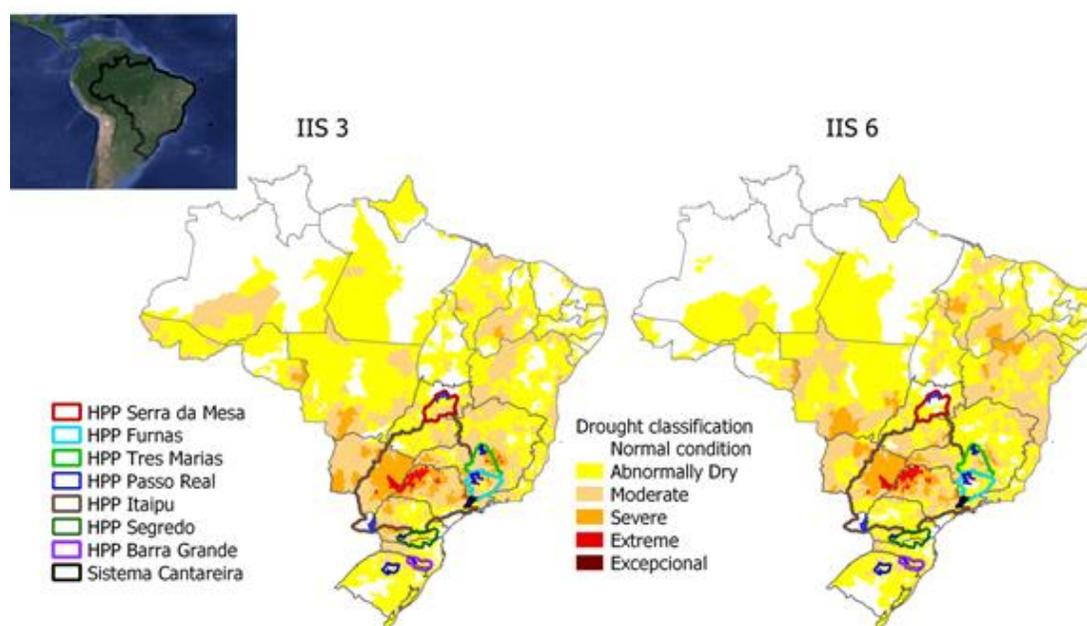


Figure 12: Integrated Drought Index (IDI) / Índice Integrado de Seca (IIS), using VHI, REW, and SPI for May 2021 at temporal scale of 3 (left) and 6 (right) months.

The driving index for the CEMADEN and GDO indicators is SPI, which explains the agreement between the results. The value of the IDI for May 2021, compared with April, exhibits drought conditions over most of the country, with intensification over regions Central-West Brazil (Região Centro-Oeste do Brasil), Southeast Brazil (Região Sudeste do Brasil) and South Brazil (Região Sul do Brasil). Overall, moderate to extreme drought conditions predominate over the states of Mato Grosso do Sul (including the Pantanal region) and São Paulo. When compared with April 2021, an intensification of drought conditions was observed over the central part of the state of Minas Gerais, over the state of Mato Grosso do Sul, and over the western part of the Northeast

¹¹ Contributed by Dr. Marcelo Zeri, Dr. Ana Paula Martins do Amaral Cunha, Dr. Luz Adriana Cuartas, Dr. José A. Marengo

region (Região Nordeste do Brasil). Conversely, decreasing drought was observed over most of the South region, except for its western part.

Reported impacts

Brazilian authorities have declared a drought emergency for the Paraná basin and all sectors affected by the drought in the region, until November 2021^{12 13}.

Reservoirs and rivers levels are very low for the period, the worst on record for many of them as of early May 2021, and essentially unchanged since then^{14 15}. Both Brazil and Paraguay are highly dependent on hydropower: shrinking reservoirs are threatening hydroelectric generation and, as drought hits hydropower production, electricity prices are set to increase, with potential consequences on inflation^{16 17}.

According to information from CEMADEN¹⁸, the Itaipu Hydropower Plant (HPP) recorded inflow of 46% of the long-term mean, the lowest ever recorded for May during the interval 1993-2020. The Segredo HPP presented inflow values below the long-term mean since March 2021, with inflow of 25% of the long-term mean in May. The Passo Real HPP, has inflow of 39% of the average value for May. Over Central Brazil, the inflow of Serra da Mesa HPP was 69% of the mean, while the reservoir level at the end of May was at 37% of full capacity. Over the Southeast Brazil, the Furnas HPP registered an inflow of 45% of the mean, with its reservoir at only 37% of full capacity. The reservoir at the Três Marias HS has 66% of its capacity, with inflow of 45% of the mean for May. Finally, for the Cantareira System, the main water supply for the Metropolitan Region of São Paulo, the inflow was of 34% of the mean, which represents 48% of the full capacity reservoir. It is lower than the value of 58% for May 2020.

Authorities may grant transitory waivers on minimum flows regulations for power production, albeit those may affect transportation, ecosystems and other uses downstream. The Paraná waterway is key to maintain the export capacity needed for Brazilian agricultural products, as well as for Paraguay and Argentina economies downstream, and negotiations on the best

¹² <https://www.gov.br/ana/pt-br/assuntos/monitoramento-e-eventos-criticos/eventos-criticos/salas-de-acompanhamento/Paraná/ResolucaoANA771junho2021.pdf>

¹³ <https://g1.globo.com/economia/blog/ana-flor/post/2021/05/28/comite-do-governo-emite-alerta-de-risco-hidrico-e-tenta-evitar-acionamento-de-energia.ghtml>

¹⁴ https://www.gov.br/ana/pt-br/assuntos/monitoramento-e-eventos-criticos/eventos-criticos/salas-de-acompanhamento/Paraná/NTC_3_2021_ANA.pdf

¹⁵ <https://www.gov.br/ana/pt-br/assuntos/monitoramento-e-eventos-criticos/eventos-criticos/salas-de-acompanhamento/Paraná/documentos/2o-reuniao-gta-Paraná-17jun21.pdf>

¹⁶ <https://www.batimes.com.ar/news/economy/historic-drought-threatens-brazils-economy.phtml>

¹⁷ <https://g1.globo.com/economia/noticia/2021/04/30/conta-de-luz-fica-mais-cara-em-maio-e-tera-bandeira-vermelha-1-define-aneel.ghtml>

¹⁸ Personal communication: Dr. Marcelo Zeri, Dr. Ana Paula Martins do Amaral Cunha, Dr. Luz Adriana Cuartas, Dr. José A. Marengo

tradeoffs are open at government level¹⁹. Water supply is not at risk overall as of June 2021, with some exceptions²⁰, and government is keen to avoid water rationing²¹.

Concerning agriculture, more than two thirds of the affected area is used for agro-pastoralism (crop and livestock production) and drought has direct negative impacts on the sector. Strong impacts are expected on livestock in Mato Grosso do Sul and western São Paulo²². EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária, Brazilian Agricultural Research Corporation) flags at risk the irrigated land and agricultural crops with long cycles, such as coffee, sugarcane, fruit and forest species. Impacts seem to be already confirmed on coffee, for example, and its price is expected to go up²³. As a matter of facts, according to assessments for May 2021²⁴, 2445 municipalities (approximately 50% of the total number of municipalities of Brazil) showed at least 40% of its crop areas under drought. Overall, the regions most affected are Southeast and South Brazil, with 63% and 56% of municipalities, respectively, with more than 40% of crop areas under drought.

Although not directly related to the drought analysis presented here, drought drives wildfire hazard, which currently classified as moderate to high in most of the upper Paraná basin (Figure 13), including the Pantanal area. There, prospects are bad for the incoming fire season²⁵, after an already extremely dry 2020, a situation of increasing detriment to the ecosystems.

¹⁹ <https://www.gov.br/ana/pt-br/assuntos/monitoramento-e-eventos-criticos/eventos-criticos/salas-de-acompanhamento/parana/documentos/oficio-rec-650-2021-se-minf-1.pdf>

²⁰ <https://www.aen.pr.gov.br/modules/noticias/article.php?storyid=113133&tit=Estiagem-mantem-impacto-na-RMC-e-afeta-bacias-dos-rios-Paraná-e-Iguacu>

²¹ <https://g1.globo.com/sp/sao-paulo/noticia/2021/05/28/governo-federal-emite-alerta-de-emergencia-hidrica-para-estado-de-sp-de-junho-a-setembro-previsao-e-de-seca-para-o-periodo.ghtml>

²² <https://www.embrapa.br/busca-de-noticias/-/noticia/62597909/artigo-mapeamento-das-areas-afetadas-pela-estiagem-no-brasil>

²³ <https://www.aen.pr.gov.br/modules/noticias/article.php?storyid=112775&tit=Boletim-agropecuario-aponta-retracao-de-9-na-producao-de-cafe-e-valorizacao-no-preco>

²⁴ Source: CEMADEN, personal communication from Dr. Marcelo Zeri, Dr. Ana Paula Martins do Amaral Cunha, Dr. Luz Adriana Cuartas, Dr. José A. Marengo

²⁵ <https://news.trust.org/item/20210527151317-4dqdq>

GDO Analytical Report

Drought in centre-south Brazil – June 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 22/06/2021

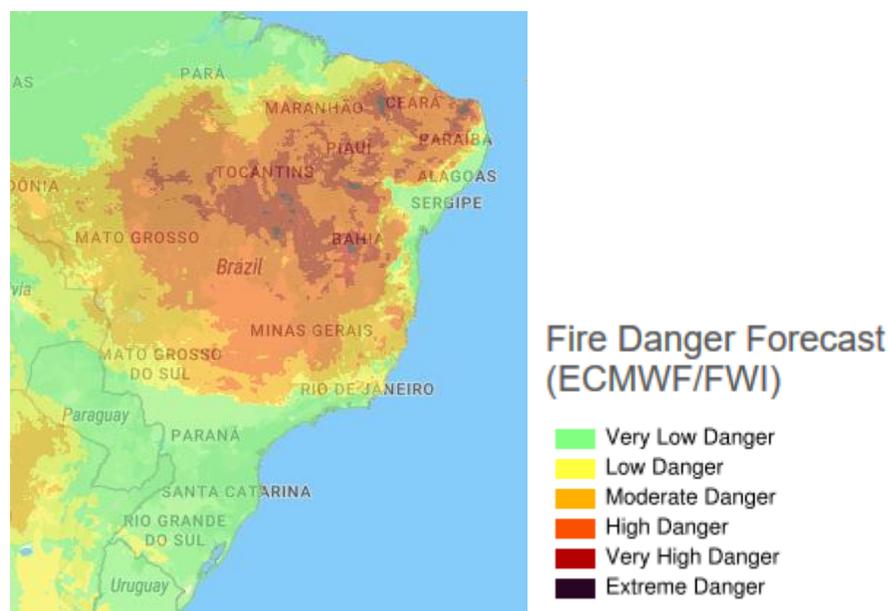


Figure 13: Fire danger forecast according to the Fire Weather Index, 21st of June 2021. Source: Global Wildfire Information System , GWIS²⁶



Figure 14: Map of Brazilian States (Credits: I, , CC BY-SA 3.0, via Wikimedia Commons).

²⁶ https://gwis.jrc.ec.europa.eu/apps/gwis_current_situation/

GDO Analytical Report

Drought in centre-south Brazil – June 2021

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) - 22/06/2021



Distribution: For use by the ERCC and related partners, and publicly available for download at GDO website: <https://edo.jrc.ec.europa.eu/reports>

Authors:

Barbosa P.ⁱ

Bavera D.ⁱⁱ

Masante D.ⁱ

Cammalleri C.ⁱ

Magni D.ⁱⁱ

McCormick N.ⁱ

Naumann G.ⁱ

Spinoni J.ⁱ

Disclaimer and Legal Notice: this report by the Joint Research Centre (JRC) is a product under constant development and may change at any time without notice. It was generated using Copernicus Emergency Management Service information (2021). The views expressed may not be regarded as an official position of the European Commission (EC) in any circumstances. The designations employed and the presentation of material on the map do not imply the expression of any opinion whatsoever on the part of the European Union concerning the legal status of any country, territory or area or of its authorities or concerning the delimitation of its frontiers or boundaries.



European Union
Civil Protection and
Humanitarian Aid



ⁱ Joint Research Centre (JRC) of the European Commission

ⁱⁱ Arcadia SIT, Vigevano, Italy