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Data Article

Near-real time flash drought monitoring system and dataset for Spain

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A R T I C L E I N F O

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A B S T R A C T

Flash droughts are characterized by rapid development and intensification, which makes early warning and monitoring difficult. Flash drought monitor (FDM) is a near-real time monitoring system for Spain (https://flash-drought.csic.es) based on the Standardized Precipitation Evapotranspiration Index (SPEI). Flash drought identification was based on rapid and anomalous declines in SPEI at a short time scale (1-month). Thus, FDM enables operational tracking of flash drought conditions in Spain at high spatial resolution (1.1 × 1.1 km) and high temporal frequency (weekly). Likewise, to put flash drought monitoring into a temporal context, the FDM also provides weekly flash drought conditions recorded in Spain from 1961 to the present. The FDM is a useful tool for preparedness and mitigation of flash droughts in Spain. Furthermore, the data provided by the FDM could be useful to develop future studies in relation to the flash drought in Spain.

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Specifications Table

Subject	Environmental sciences
Specific subject area	Drought analysis and monitoring
Type of data	Web-tool and dataset
How data were acquired	Daily meteorological data (precipitation, maximum and minimum air temperature, relative humidity, sunshine duration and wind speed) is recorded from the network of weather stations of the National Spanish Meteorological Service (AEMET). The data is subjected to quality control, aggregated weekly and interpolated to obtain gridded datasets for each meteorological variable, which are used to calculate the Standardized Precipitation Evapotranspiration Index (SPEI). Flash drought conditions are identified based on quick and abrupt declines in SPEI at a 1-month time scale.
Data format	Filtered and analyzed. netCDF (network Common Data Form) and CSV (comma-separated values)
Description of data collection	Flash drought conditions are collected for each pixel (1.1 × 1.1 km) at weekly frequency across Spain. Flash drought condition is defined as a decline $\geq$2 in SPEI 1-month values over 4-week period that results in a final SPEI value equal or less than −1.28 (moderate drought; corresponding with a 10-year return period). Flash conditions identified for each pixel are encoding as follows: value = 0 (no flash drought) value = 1 (flash drought onset), value = 2 (1st week from onset), value = 3 (2nd week from onset), value = 4 (3rd week from onset).
Data source location	Institution: Climatology and Climate Services Laboratory (LCSC). City: Zaragoza (Aragón) Country: Spain
Data accessibility	Users can download and visualize the data on flash drought conditions in Spain at the Climatology and Climate Services Laboratory (LCSC) website: https://flash-drought.csic.es Likewise, the FDM input and output data is available in an open access repository; Repository name: Zenodo, Title of the dataset: Flash drought monitor (FDM) datasets, URL: https://zenodo.org/record/7434135, DOI: 10.5281/zenodo.7434135.
Related research article	I. Noguera, F. Domínguez-Castro, S.M. Vicente-Serrano, Characteristics and trends of flash droughts in Spain, 1961–2018, Ann. N. Y. Acad. Sci. 1472 (2020) 155–172, doi:10.1111/nyas.14365. S.M. Vicente-Serrano, F. Domínguez-Castro, F. Reig, S. Beguería, M. Tomas-Burguera, B. Latorre, D. Peña-Angulo, I. Noguera, I. Rabanaque, Y. Luna, A. Morata, A. el Kenawy, A near real-time drought monitoring system for Spain using automatic weather station network, Atmos. Res. 271 (2022), doi:10.1016/J.ATMOSRES.2022.106095.

Value of the Data

- Flash drought monitor (FDM) provides detailed information on flash drought conditions for the whole of Spain at near-real time by means a user-friendly web-tool.
- Flash drought is a complex phenomenon, difficult to identify and monitor over the time and space. The presented monitoring system allows the automatic identification and tracking of flash drought conditions at high spatial resolution (1.1 × 1.1 km) and temporal frequency (weekly). Thus, FDM is an operative tool to early warning and decision-making by land and water managers.
- The information presented in this monitoring system was obtained by means of a robust method to identify flash drought conditions [1], which is based on Standardized Precipitation Evapotranspiration Index (SPEI) at a 1-month time scale.

- Flash drought is a frequent phenomenon in Spain, representing around 40% of all droughts recorded at short-term. Furthermore, this type of events can occur in any season, resulting in major and diverse impacts on agricultural, environmental and socioeconomic systems. Therefore, the FDM represents a relevant and useful tool and data source for preparedness and mitigation of flash droughts in Spain.
- The data available in the FDM could be used by the scientific community to develop futures studios focused on flash drought in Spain.

1. Objective

The main objective of the Flash drought monitor (FDM) is to provide near real-time information about flash drought conditions in Spain by means a user-friendly web-tool, making it easily accessible and comprehensible by users. This information is crucial for preparedness and mitigation of flash droughts in Spain, representing a useful tool to early warning and decision-making by agricultural and water managers. In order to provide a temporal context of flash drought occurrence in Spain, the FDM also includes weekly data about flash droughts conditions recorded from 1961 to the present. In addition, all data presented in FDM are available for download by users and may be useful for future research on flash droughts in Spain.

2. Data Description

The Flash drought monitor (FDM) is available at https://flash-drought.csic.es. This monitoring system provides high spatial (1.1 × 1.1 km) and temporal (weekly) resolution data on flash drought conditions in Spain. The FDM allows near-real time monitoring of the spatial extent of flash droughts and their evolution over time, using a simple color code to indicate the number of weeks elapsing from the onset of a flash drought (i.e., from onset week for pixels where a flash drought has just been recorded to 3rd week for pixels where it was recorded 3 weeks previously). The definition adopted to identify flash droughts is always displayed at the bottom of the screen, while hovering the mouse over the top left shows details of the legend. Fig. 1 shows an example of the general display of the FDM during one of the last flash drought episodes recorded in Spain.

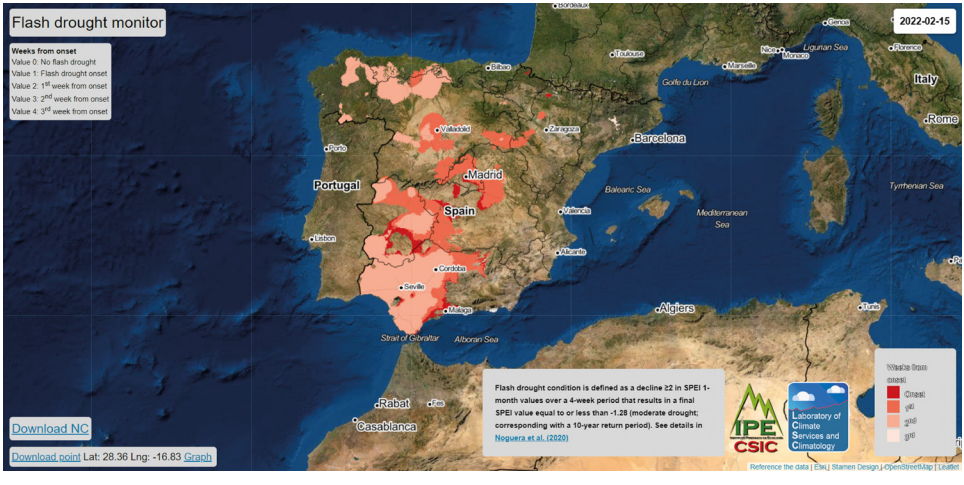

Fig. 1. Flash drought conditions recorded over mainland Spain and Balearic Island at 02/15/2022 by the FDM.

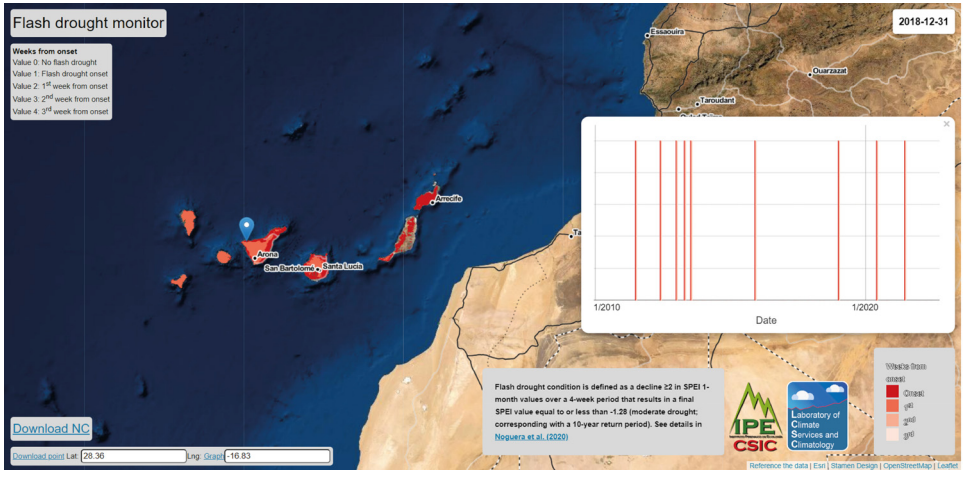

Fig. 2. Flash drought conditions recorded over the Canary Islands at 12/31/2018, as well as the temporal evolution of flash drought conditions in a specific pixel over the period 2010–2022.

The home map shows the information on flash drought conditions in the last week available, but weekly maps of flash drought conditions from 1961 to the present can also be displayed, allowing users to visualize the evolution of any of the flash droughts affecting Spain over the last six decades. In addition, the flash drought conditions recorded in each pixel over the weekly time series can be also visualized by selecting a point on the map by means of an interactive graph, with the option to zoom in on a specific period (Fig. 2).

All data presented in the FDM is available for download in netCDF (network Common Data Form) and CSV (comma-separated values) format using the box at the bottom left. At regional scale, a netCDF file is provided with all flash drought events recorded in Spain from 1961 to the present. This netCDF file contains weekly series sorted by year for the whole of Spain (i.e., a grid of 1570 rows and 1257 columns, containing 418,597 grid points with data), with the following encoding: value = 0 (no flash drought), value = 1 (flash drought onset), value = 2 (1st week from onset), value = 3 (2nd week from onset), value = 4 (3rd week from onset). At pixel scale, CSV files are provided, with record of flash droughts identified from 1961 to the present in each pixel of the gridded dataset. These files can be downloaded by selecting any pixel in the study area to obtain a CSV file that contains weekly data sorted by year with the same encoding as described above.

3. Experimental Design, Materials and Methods

3.1. The Relevance of Flash Droughts in Spain

Spain is one of the regions most affected by drought in Europe, with heavy impacts on crops [2], forestry [3] and water resources [4]. Likewise, drought events commonly termed as “flash droughts” [5] are also frequent in Spain, representing almost 40% of all droughts identified [1]. Flash drought is distinguished from conventional slower-onset droughts by its rapid development and intensification linked to strong precipitation deficits and/or anomalous increases in atmospheric evaporative demand (AED) (e.g., associated with heat waves), triggering an abrupt decline in soil moisture and stress on vegetation, which can cause major agricultural and environmental impacts [6]. In Spain, flash droughts show wide spatiotemporal variability and remarkable seasonal differences [1]. Thus, flash drought in Spain may occur in any season associ-

ated with different meteorological drivers [7,8], causing diverse impacts. For these reasons, there is a need for flash drought monitoring and early warning in Spain.

3.2. Drought Index Calculation

These days, the Standardized Precipitation Evapotranspiration Index (SPEI) is the most widely used metric of drought severity worldwide [9]. The SPEI has been employed in numerous studies to analyze drought impacts on agriculture [10,11], hydrology [12,13] and environmental [14,15] systems in different regions of the world. The SPEI is calculated by the difference between precipitation and AED (i.e., climatic balance), which is accumulated at different time scales and standardized in order to be spatially and temporally comparable.

Daily data on precipitation, maximum and minimum air temperature, relative humidity, sunshine duration and wind speed from the complete network of weather stations in the National Spanish Meteorological Service (AEMET), which includes automatic stations (AWS), are used to generate SPEI real-time data for the whole of Spain. AED is computed based on maximum and minimum air temperature, relative humidity, sunshine duration and wind speed by means of the FAO-56 Penman–Monteith equation [16]. SPEI series are calculated at a 1-month time scale and high spatial (1.1×1.1 km) and temporal (weekly) resolution using the Log-logistic distributions as recommended by Vicente-Serrano and Beguería [17]. Additional information about generation and validation of meteorological datasets are available in Vicente-Serrano et al. [18].

To use SPEI for monitoring purposes, the AWS data undergo exhaustive quality control [19], aggregated weekly and then spatially interpolated using Universal Kriging as soon as new meteorological data are available to generate new SPEI values for the whole of Spain (see all details in Vicente-Serrano et al. [20]).

3.3. Flash Drought Monitoring

Flash drought events were identified following the method proposed by Noguera et al. [1], which is focused on the rapid development and intensification characteristic of this type of events [6]. In order to avoid the influence of past climatic conditions and only consider climatic anomalies developed at short-term, this approach is based on rapid changes in SPEI values at short time scales (i.e., 1-month) over 4-week periods. Thus, a flash drought event is defined as:

(i) A minimum length of four weeks in the development phase.
(ii) A ΔSPEI (in 4 weeks) equal to or less than -2 z-units.
(iii) A final SPEI value equal to or less than -1.28 z-units (i.e., a 10-year return period).

This definition was applied to the SPEI 1-month weekly series of each pixel to obtain a flash drought record over the lasts six decades in Spain. Similarly, we adopted this definition to identify flash drought events at near-real time as new SPEI data are available and to generate a flash drought monitoring system. Fig. 3 summarizes the process followed for the FDM to monitor flash drought conditions in Spain at near-real time.

To illustrate the performance and usefulness of the FDM, we show two representative examples of recent flash drought events in Spain (Fig. 4). The 2021 flash drought affected large areas of the country in March and early April associated with notable precipitation deficits, which resulted in the driest March of this century in Spain [21]. Despite normal temperatures, the marked lack of precipitation during the entire month triggered flash drought conditions in some areas of the northwest in late March that quickly spread to some areas of southern and large areas of northeastern Spain in early April. The 2022 flash drought hit most of Spain over May and June as a result of the combination of precipitation deficits and a high AED, reaching markedly anomalous temperatures in both months [22,23]. The flash drought started in the northeast and the Balearic Islands in late May and then affected all of eastern Spain in early June. These examples highlight the ability of the FDM to identify events with different characteristics, which

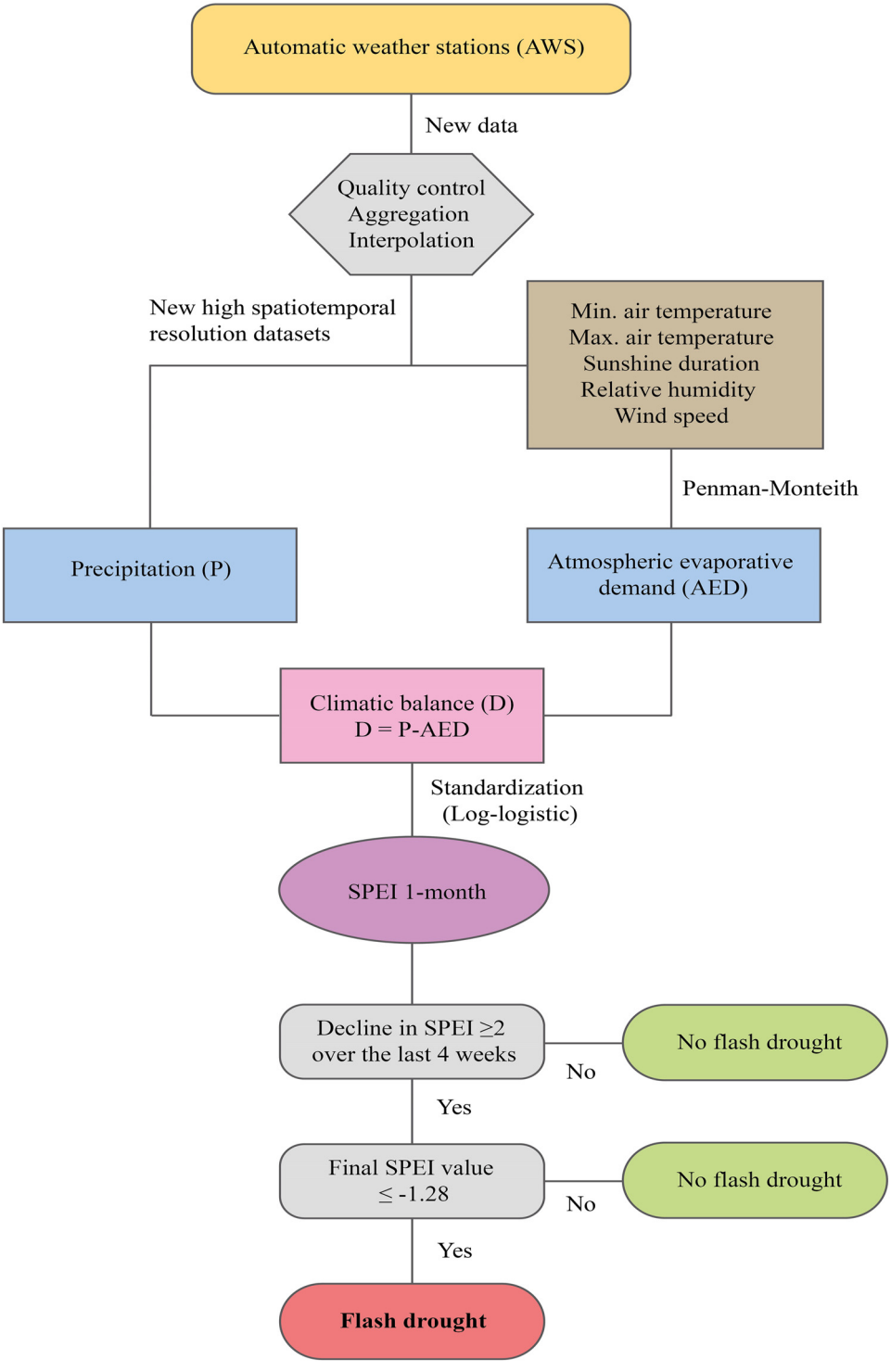

Fig. 3. Summary of the process followed for the monitoring of flash drought conditions.

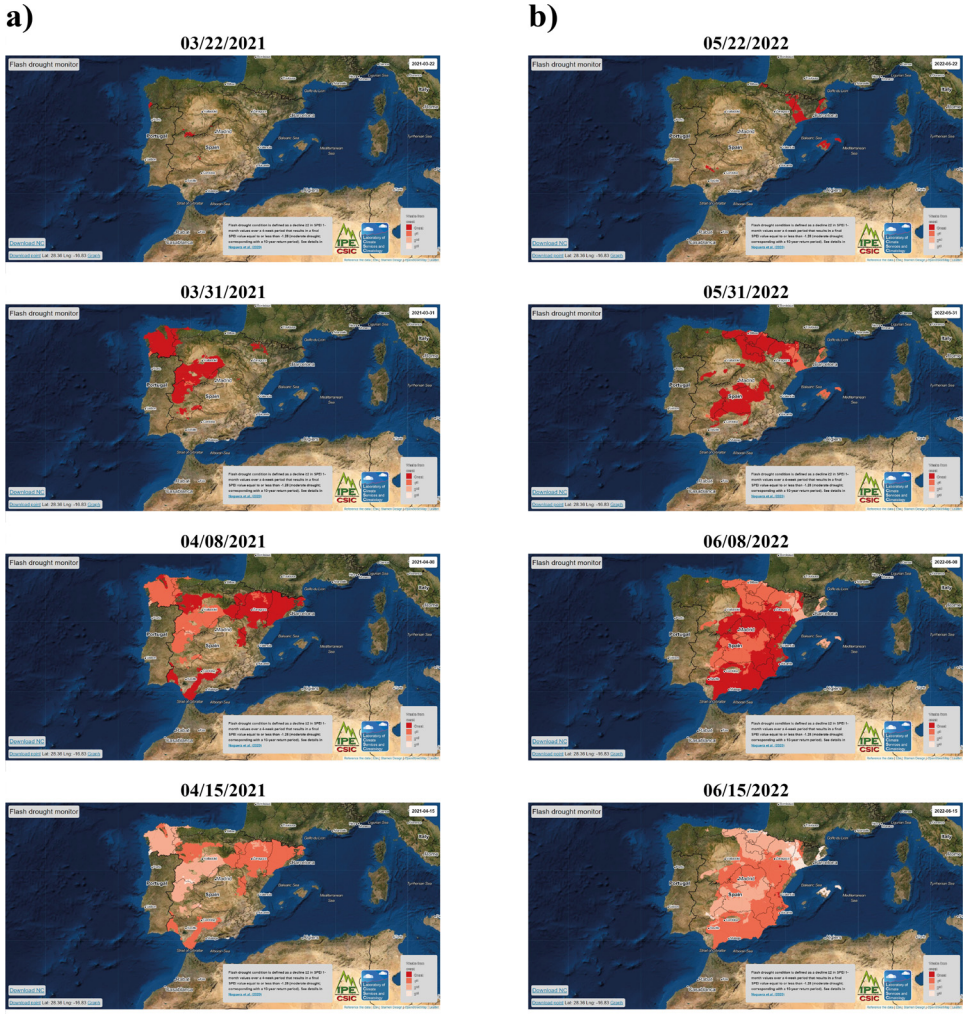

Fig. 4. The **(a)** March-April 2021 and **(b)** May-June 2022 flash drought events recorded by the FDM.

is crucial in Spain as flash droughts can occur at any period of the year related with different drivers.

Ethics Statement

This work did not involve human subjects, animal experiments and data collected from social media platforms.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Flash drought monitor (FDM) (Original data) (https://flash-drought.csic.es).

CRediT Author Statement

I. Noguera: Conceptualization, Methodology, Formal analysis, Visualization, Validation, Writing – original draft, Writing – review & editing; **F. Domínguez-Castro:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing; **S.M. Vicente-Serrano:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing; **F. Reig:** Formal analysis, Visualization, Validation, Writing – original draft, Writing – review & editing.

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References

[1] I. Noguera, F. Domínguez-Castro, S.M. Vicente-Serrano, Characteristics and trends of flash droughts in Spain, 1961–2018, Ann. N. Y. Acad. Sci. 1472 (2020) 155–172, doi:10.1111/nyas.14365.
[2] M. Peña-Gallardo, S.M. Vicente-Serrano, F. Domínguez-Castro, S. Beguería, The impact of drought on the productivity of two rainfed crops in Spain, Nat. Hazards Earth Syst. Sci. 19 (2019) 1215–1234, doi:10.5194/nhess-19-1215-2019.
[3] M. Peña-Gallardo, S. Vicente-Serrano, J. Camarero, A. Gazol, R. Sánchez-Salguero, F. Domínguez-Castro, A. el Kenawy, S. Beguería-Portugés, E. Gutiérrez, M. de Luis, G. Sangüesa-Barreda, K. Novak, V. Rozas, P. Tíscar, J. Linares, E. Martínez del Castillo, M. Ribas Matamoros, I. García-González, F. Silla, Á. Camisón, M. Génova, J. Olano, L. Longares, A. Hevia, J. Galván, Drought sensitiveness on forest growth in peninsular Spain and the Balearic Islands, Forests 9 (2018) 524, doi:10.3390/f9090524.
[4] J. Lorenzo-Lacruz, E. Morán-Tejeda, S.M. Vicente-Serrano, J.I. López-Moreno, Streamflow droughts in the Iberian peninsula between 1945 and 2005: spatial and temporal patterns, Hydrol. Earth Syst. Sci. 17 (2013) 119–134, doi:10.5194/hess-17-119-2013.
[5] M. Svoboda, D. LeComte, M. Hayes, R. Heim, K. Gleason, J. Angel, B. Rippey, R. Tinker, M. Palecki, D. Stooksbury, D. Miskus, S. Stephens, The drought monitor, Bull. Am. Meteorol. Soc. 83 (2002) 1181–1190, doi:10.1175/1520-0477(2002)083⟨1181:TDM⟩2.3.CO;2.
[6] J.A. Otkin, M. Svoboda, E. Hunt, T.W. Ford, M.C. Anderson, C. Hain, J.B. Basara, Flash droughts: a review and assessment of the challenges imposed by rapid-onset droughts in the United States, Bull. Am. Meteorol. Soc. 99 (2018) 911–919, doi:10.1175/BAMS-d-17-0149.1.
[7] I. Noguera, S.M. Vicente-Serrano, F. Domínguez-Castro, The rise of atmospheric evaporative demand is increasing flash droughts in Spain during the warm season, Geophys. Res. Lett. 49 (2022), doi:10.1029/2021GL097703.
[8] I. Noguera, F. Domínguez-Castro, S.M. Vicente-Serrano, Flash drought response to precipitation and atmospheric evaporative demand in Spain, Atmosphere 12 (2021) 165 Basel, doi:10.3390/atmos12020165.
[9] M.W. Kim, M.E. Park, H.W. Jo, M. Roh, J. Kim, C. Song, W.K. Lee, A meta-analytic review on the spatial and climatic distribution of meteorological drought indices, Environ. Rev. (2022), doi:10.1139/ER-2021-0098.
[10] V. Potop, M. Možný, J. Soukup, Drought evolution at various time scales in the lowland regions and their impact on vegetable crops in the Czech Republic, Agric. For. Meteorol. 156 (2012) 121–133, doi:10.1016/J.AGRFORMET.2012.01.002.
[11] M. Peña-Gallardo, S.M. Vicente-Serrano, F. Domínguez-Castro, S. Quiring, M. Svoboda, S. Beguería, J. Hannaford, Effectiveness of drought indices in identifying impacts on major crops across the USA, Clim. Res. 75 (2018) 221–240, doi:10.3354/cr01519.
[12] M. Peña-Gallardo, S.M. Vicente-Serrano, J. Hannaford, J. Lorenzo-Lacruz, M. Svoboda, F. Domínguez-Castro, M. Maneta, M. Tomas-Burguera, A. el Kenawy, Complex influences of meteorological drought time-scales on hydrological droughts in natural basins of the contiguous Unites States, J. Hydrol. 568 (2019) 611–625 Amst, doi:10.1016/J.JHYDROL.2018.11.026.
[13] D.J. McEvoy, J.L. Huntington, J.T. Abatzoglou, L.M. Edwards, An evaluation of multiscalar drought indices in Nevada and Eastern California, Earth Interact. 16 (2012) 1–18, doi:10.1175/2012EI000447.1.

[14] S.M. Vicente-Serrano, C. Gouveia, J.J. Camarero, S. Begueria, R. Trigo, J.I. Lopez-Moreno, C. Azorin-Molina, E. Pasho, J. Lorenzo-Lacruz, J. Revuelto, E. Moran-Tejeda, A. Sanchez-Lorenzo, Response of vegetation to drought time-scales across global land biomes, Proc. Natl. Acad. Sci. 110 (2013) 52–57, doi:10.1073/pnas.1207068110.
[15] S.M. Vicente-Serrano, J.J. Camarero, C. Azorin-Molina, Diverse responses of forest growth to drought time-scales in the Northern Hemisphere, Glob. Ecol. Biogeogr. 23 (2014) 1019–1030, doi:10.1111/geb.12183.
[16] R.G. Allen, L.S. Pereira, D. Raes, M. Smith, Crop evapotranspiration: guidelines for computing crop water requirements, FAO Irrigation and drainage paper 56 (1998).
[17] S.M. Vicente-Serrano, S. Beguería, Comment on "Candidate distributions for climatological drought indices (SPI and SPEI)" by James H. Stagge et al, Int. J. Climatol. 36 (2016), doi:10.1002/joc.4474.
[18] S.M. Vicente-Serrano, M. Tomas-Burguera, S. Beguería, F. Reig, B. Latorre, M. Peña-Gallardo, M.Y. Luna, A. Morata, J.C. González-Hidalgo, A high resolution dataset of drought indices for Spain, Data 2 (2017) 22 Basel, doi:10.3390/data2030022.
[19] M. Tomás-Burguera, A.J. Castañeda, M.Yolanda. Luna, A. Morata, S.M. Vicente-Serrano, J.C. Gonzalez-Hidalgo, S. Begueria, Control de calidad de siete variables del banco nacional de datos de AEMET, in: Proceedings of the X Congreso Internacional AEC: Clima, Sociedad, Riesgos y Ordenación Del Territorio, Alicante, Spain, 2016, pp. 407–415. http://repositorio.aemet.es/handle/20.500.11765/8056..
[20] S.M. Vicente-Serrano, F. Domínguez-Castro, F. Reig, S. Beguería, M. Tomas-Burguera, B. Latorre, D. Peña-Angulo, I. Noguera, I. Rabanaque, Y. Luna, A. Morata, A. el Kenawy, A near real-time drought monitoring system for Spain using automatic weather station network, Atmos. Res. 271 (2022), doi:10.1016/J.ATMOSRES.2022.106095.
[21] Agencia Estatal de Meteorología (AEMET), El marzo más seco de este siglo, (2021). https://www.aemet.es/es/noticias/2021/04/resumen_clima_marzo_2021. Accessed September 19, 2022.
[22] Agencia Estatal de Meteorología (AEMET), Mayo de 2022, el más cálido de este siglo y el segundo más seco de la serie, (2022). https://www.aemet.es/es/noticias/2022/06/resumen_clima_mayo_2022. Accessed September 19, 2022.
[23] Agencia Estatal de Meteorología (AEMET), Junio de 2022, otro mes más muy alejado de las medias, (2022). https://www.aemet.es/es/noticias/2022/07/resumen_clima_junio_2022. Accessed September 19, 2022.