CROSSDRO

ANNUAL NEWSLETTER 2022

Research partners:

Supported by:

February 2023

What is CROSSDRO?

CROSSDRO (*CROSS-sectoral impact assessment of DROughts in complex European basins*) is a EU JPI AXIS project that runs from September 2019 to March 2023. The CROSSDRO objectives are to:

- Better understand the multi- and cross-sectoral impact of droughts including the connection between physical and socioeconomic impacts and pathways.
- Better understand stakeholder needs and perceptions of drought.
- Examine drought impact across scales – catchment to European scale, and both historically and into the future.
- Our research is organised around the six work packages as shown in the Figure below
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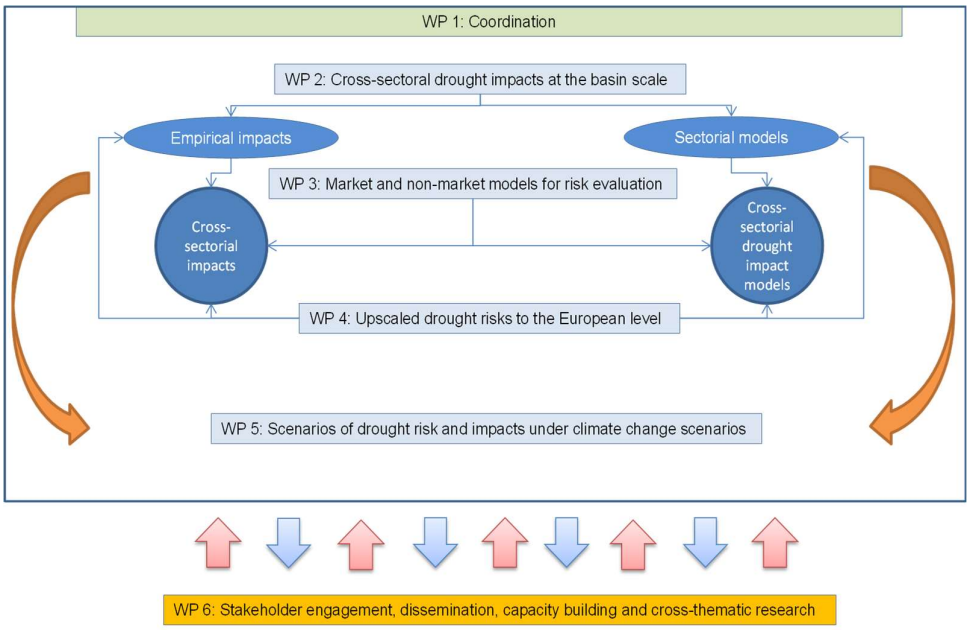


Where is the research taking place?

CROSSDRO is analysing drought in four European basins with different socio-ecological contexts and at the wider European scale. Case study basins include:

i) the upper Aragon basin in Northeast Spain,

ii) the German part of the Elbe basin,

iii) the Boyne basin in Ireland.

iv) the Moldovan part of Prut basin.

Who is involved?

CROSSDRO brings together scientists from five research institutions. The leading institution is the Spanish National Research Council, and the project coordinator is Sergio Vicente-Serrano. Partner institutions are University of Maynooth in Ireland (group leader C. Murphy), Lund University in

Sweden (group leader L. Eklundh), Research Institute of Field Crops “Selectia” in Moldova (group leader B. Boincean) and Potsdam Institute for Climate Impact Research in Germany (group leader T. Conradt).

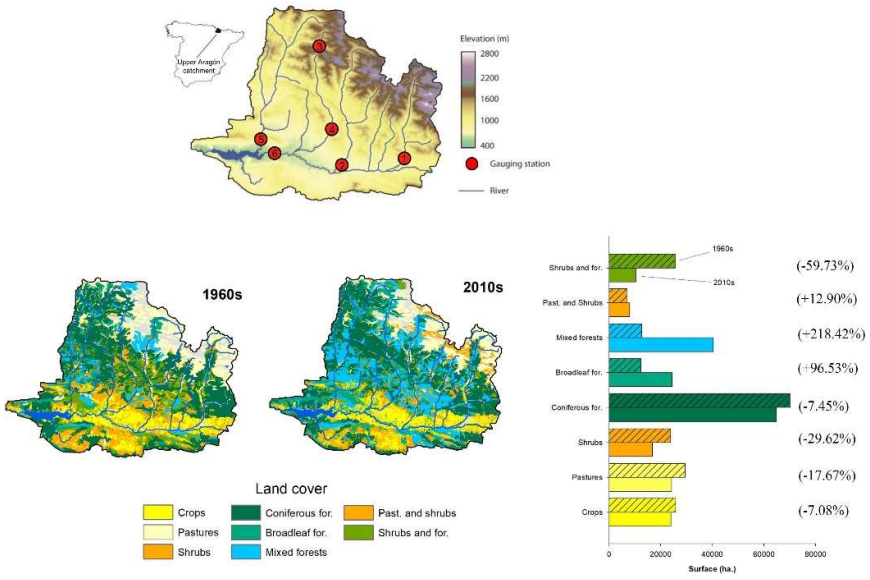
Progress in 2022

We are now approaching the end of the project and provide an update on the latest developments from the project in what has been a very busy 2022. The sections below highlight our scientific outputs, stakeholder engagement activities, media that our researchers have featured in and conference presentations we have delivered. If you have any questions or would like further details on any aspect, please get in contact with us. Contact details are available on the project website https://crossdro.csic.es/

Scientific Outputs

Hydro-climatic time-series and vegetation trends of the Upper Aragón catchment

Juez, C., Garijo, N., Nadal-Romero, E., Vicente-Serrano, S.M., (2022) Wavelet analysis of hydro-climatic time-series and vegetation trends of the Upper Aragón catchment (Central Spanish Pyrenees). Journal of Hydrology, 614: 128584



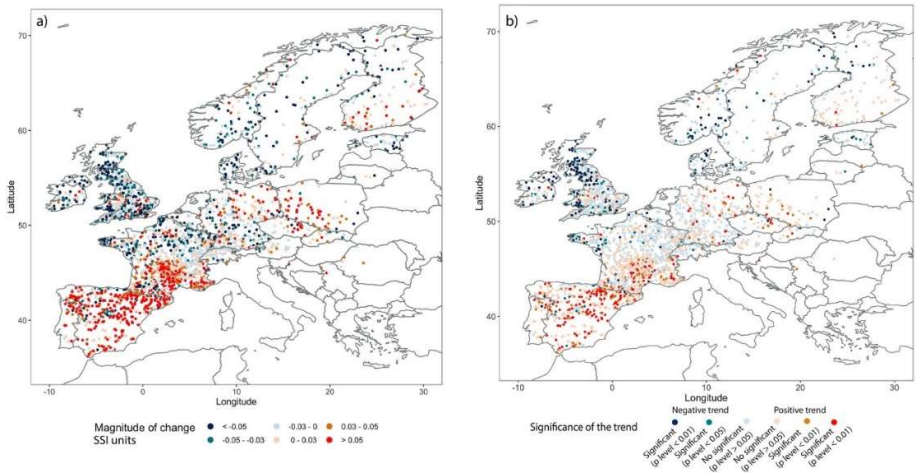
The Upper Aragón catchment location and topography with the gauging stations (top). Land-cover categories for 1960s and 2010s.

Water managers and researchers noted with concern a nearly generalized decline in Mediterranean rivers discharge over the last decades. Changes in climatic forces (precipitation and air temperature) and land use and land cover (LULC) changes characterized by re-vegetation and greenness are the two most possible explanations for this discharge decline. The direct impact on river discharge stemming from these changes is difficult to assess and their role is generally studied separately. Here, we use the method of wavelet transformation to interpret the time-scale dependency of catchment

discharge concerning the uneven temporal climatic fluctuations and re-vegetation processes. We analyzed the temporal variation of concurrent air temperature, precipitation and river discharge time-series for the Upper Aragón catchment, located in the Central Spanish Pyrenees. A long-term database collected over 60 years (1956–2020) was used. Land cover maps corresponding to different decades were used and the results indicated that the catchment experienced a significant increase in the area covered by mixed and broadleaf forests, mostly as a consequence of land abandonment. We show how temperature slightly increased and precipitation moderately decreased. However, catchment discharge experienced a sharp decline in its magnitude and also changes in its temporal variability dynamics. The relevance of the seasonal time-scales with regard to the available discharge is reduced, which strengthens the importance of the inter-annual time-scales for the catchment discharge dynamics. Furthermore, the catchment storage-discharge cycle at inter-annual time-scales is also reduced. Such changes can mostly be attributed to the changes in plant coverage, with an increasing weight in shaping hydrological processes at catchment scale due to the greenness effect. As such, we conclude that LULC changes have played a dominant role on the river discharge dynamics. Climatic trends, on the contrary, have been small, and they have played a secondary role in the decline of river discharge. Future research can use these observations to constrain the pace of upcoming water demands based on the available water resources at Mediterranean catchment scale.

The complex and spatially diverse patterns of hydrological droughts across Europe

Peña-Angulo, D., Vicente-Serrano, S.M.,, Domínguez-Castro, F., Lorenzo-Lacruz, J., Murphy, C., Hannaford, J., Allan, R., Tramblay, Y., Reig?Gracia, F, , El Kenawy, A. (2022) The complex and spatially diverse patterns of hydrological droughts across Europe. Water Resources Research, 58, e2022WR031976.



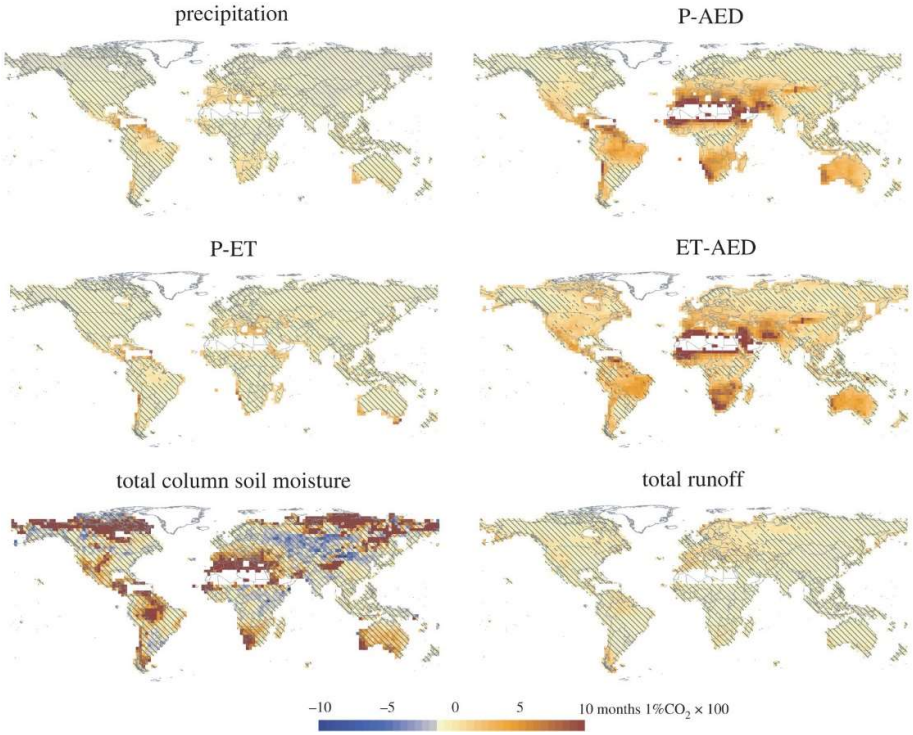
Trends in the severity of drought events from 1962 to 2017. (a) Spatial distribution of the magnitude of change in Standardized Streamflow Index (SSI) and (b) the corresponding significance of trends (at $p < 0.05$, $p < 0.01$) over the same period. Each circle represents one gauging station.

This study presents a new data set of gauged streamflow (N = 3,224) for Europe spanning the period 1962–2017. The Monthly Streamflow of Europe Dataset (MSED) is freely available at http://msed.csic.es/. Based on this data set, changes in the characteristics of hydrological drought (i.e., frequency, duration, and severity) were assessed for different regions of Europe. Due to the density of the database, it is possible to delimit spatial patterns in hydrological droughts trend with the greatest detail available to date. Results reveal bidirectional changes in monthly streamflow, with negative changes predominating over central and southern Europe, while positive trends dominate over northern Europe. Temporally, two dominant patterns were noted. The first pattern corresponds to a consistent downward trend in all months, evident for southern Europe. A second pattern was noted over central and northern Europe and western France, with a predominant negative trend

during warm months and a positive trend in cold months. For hydrological drought events, results suggest a positive trend toward more frequent and severe droughts in southern and central Europe and conversely a negative trend over northern Europe. This study emphasizes that hydrological droughts show complex spatial patterns across Europe over the past six decades, implying that hydrological drought behavior in Europe has a regional character. Accordingly it is challenging to adopt "efficient" strategies and policies to monitor and mitigate drought impacts at the continental level.

Global drought trends and future projections.

Vicente-Serrano, S.M., Peña-Angulo, D., Beguería, S., Domínguez-Castro, F., Tomás-Burguera, M., Noguera, I., Gimeno-Sotelo, L., El Kenawy, A. (2022) Global drought trends and future projections. Philosophical Transactions of the Royal Society A. A380, 2021028.

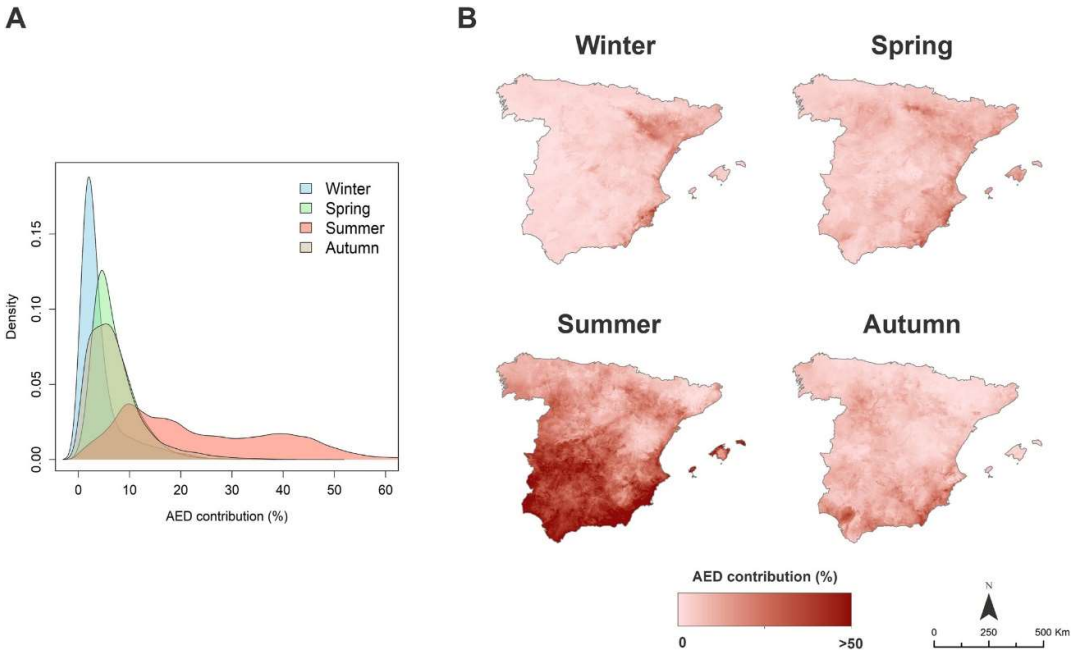


Spatial patterns of the change in drought duration between a scenario of preindustrial CO_2 concentrations and one of atmospheric CO_2 concentrations corresponding to the SSP5-85 scenario for the year 2100. The magnitude of change represents the median of the 12 models. Stripes correspond to areas in which less than 75% of the models show statistically significant changes.

Drought is one of the most difficult natural hazards to quantify and is divided into categories (meteorological, agricultural, ecological and hydrological), which makes assessing recent changes and future scenarios extremely difficult. This opinion piece includes a review of the recent scientific literature on the topic and analyses trends in meteorological droughts by using long-term precipitation records and different drought metrics to evaluate the role of global warming processes in trends of agricultural, hydrological and ecological drought severity over the last four decades, during which a sharp increase in atmospheric evaporative demand (AED) has been recorded. Meteorological droughts do not show any substantial changes at the global scale in at least the last 120 years, but an increase in the severity of agricultural and ecological droughts seems to emerge as a consequence of the increase in the severity of AED. Lastly, this study evaluates drought projections from earth system models and focuses on the most important aspects that need to be considered when evaluating drought processes in a changing climate, such as the use of different metrics and the uncertainty of modelling approaches.

The rise of Atmospheric Evaporative Demand is increasing flash droughts in Spain during the warm season

Noguera, I., Domínguez-Castro, F. Vicente-Serrano, S.M. (2022) The rise of Atmospheric Evaporative Demand is increasing flash droughts in Spain during the warm season. Geophysical Research Letters, 49, e2021GL097703

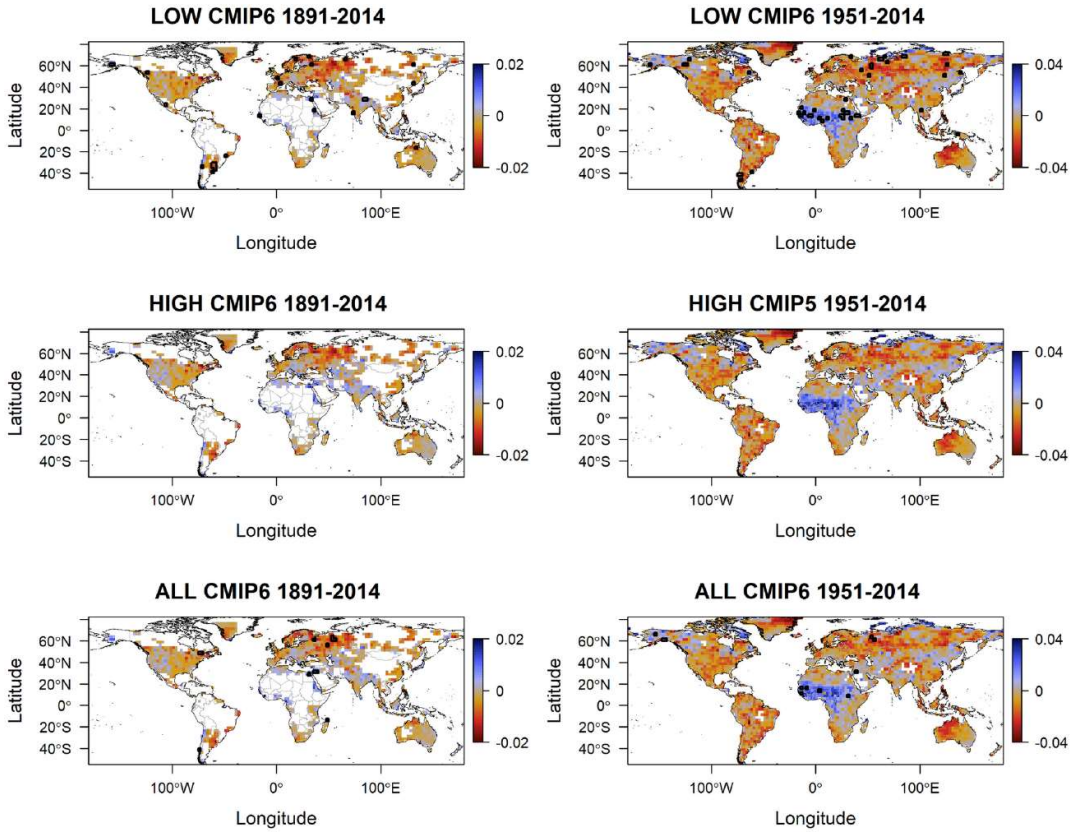


Seasonal (a) density of the average atmospheric evaporative demand (AED) contribution to the development of flash droughts and (b) its spatial distribution in mainland Spain and the Balearic Islands over the period 1961–2018.

Flash droughts are characterized by rapid development and intensification, generating a new risk for drought impacts on natural and socio-economic systems. In the current climate change scenario, the meteorological drivers involved in triggering flash droughts are uncertain. We analyzed the role of meteorological drivers underlying the development of flash droughts in Spain over the last six decades, evidencing that the effect of atmospheric evaporative demand (AED) on flash drought is mainly restricted to water-limited regions and the warm season. However, the contribution of the AED has increased notably in recent years and particularly in summer (~3.5% per decade), thus becoming a decisive driver in explaining the occurrence of the latest flash droughts in some regions of Spain. Our findings have strong implications for proper understanding of the recent spatiotemporal behavior of flash droughts in Spain and illustrate how this type of event can be related to global warming processes.

Do climate models capture observed precipitation trends?

Vicente-Serrano, S.M., García-Herrera, R., Peña-Angulo, D., Tomas-Burguera, M., Domínguez-Castro, F., Noguera, I., Calvo, N., Murphy, C., Nieto, R., Gimeno, L., Gutierrez, J.M., Azorin-Molina, C., El Kenawy, A. (2022) Do CMIP models capture observed precipitation trends? Climate Dynamics. 58, 2825-2842.

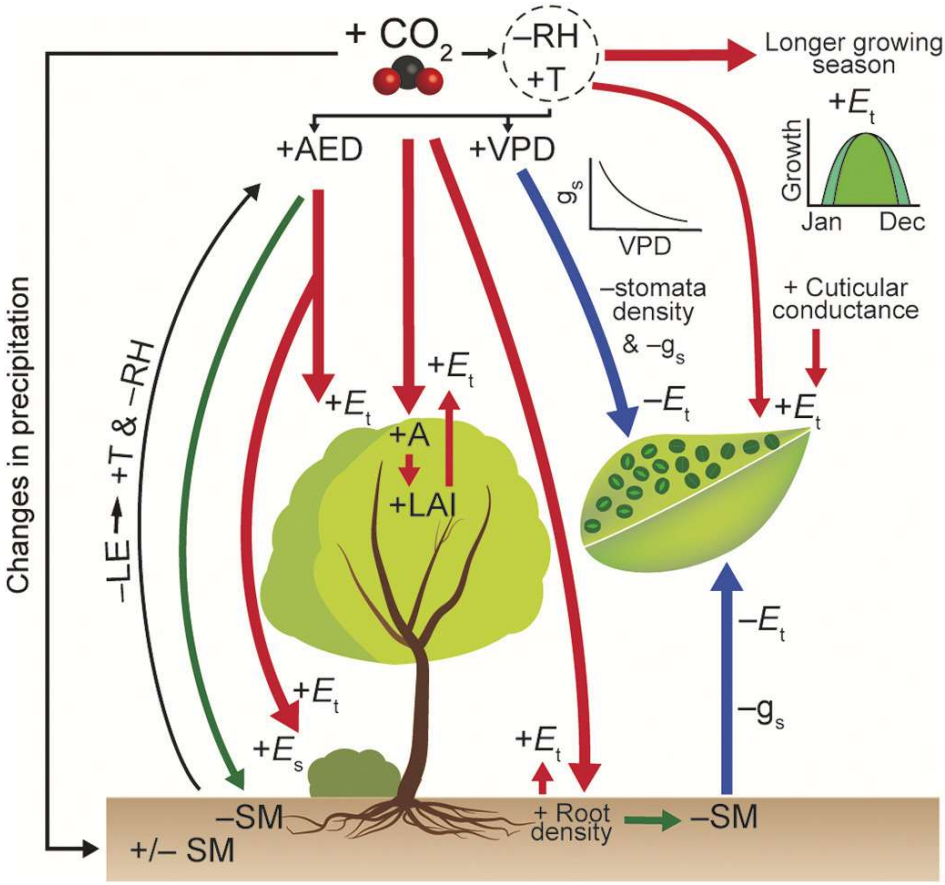


Spatial distribution of the average differences between the magnitude of change in annual precipitation of the individual models of each CMIP6 group of models and the magnitude of change in the GPCC observations. Areas with statistically significant differences between observations and model groups are delineated by black lines (90% of the models)

This study provides a long-term (1891–2014) global assessment of precipitation trends using data from two station-based gridded datasets and climate model outputs evolved through the fifth and sixth phases of the Coupled Model Intercomparison Project (CMIP5 and CMIP6, respectively). Our analysis employs a variety of modeling groups that incorporate low- and high-top level members, with the aim of assessing the possible effects of including a well-resolved stratosphere on the model's ability to reproduce long-term observed annual precipitation trends. Results demonstrate that only a few regions show statistically significant differences in precipitation trends between observations and models. Nevertheless, this pattern is mostly caused by the strong interannual variability of precipitation in most of the world regions. Thus, statistically significant model-observation differences on trends (1891–2014) are found at the zonal mean scale. The different model groups clearly fail to reproduce the spatial patterns of annual precipitation trends and the regions where stronger increases or decreases are recorded. This study also stresses that there are no significant differences between low- and high-top models in capturing observed precipitation trends, indicating that having a well-resolved stratosphere has a low impact on the accuracy of precipitation projections.

On the role of rising atmospheric CO2 on global plant transpiration.

Vicente-Serrano, Sergio M., Miralles, Diego G., McDowell, Nate, Brodribb, Tim, Domínguez-Castro, Fernando, Leung, Ruby, Koppa, Akash. (2022) On the role of rising atmospheric CO2 on global plant transpiration. Earth Science Reviews, 230, 104055.



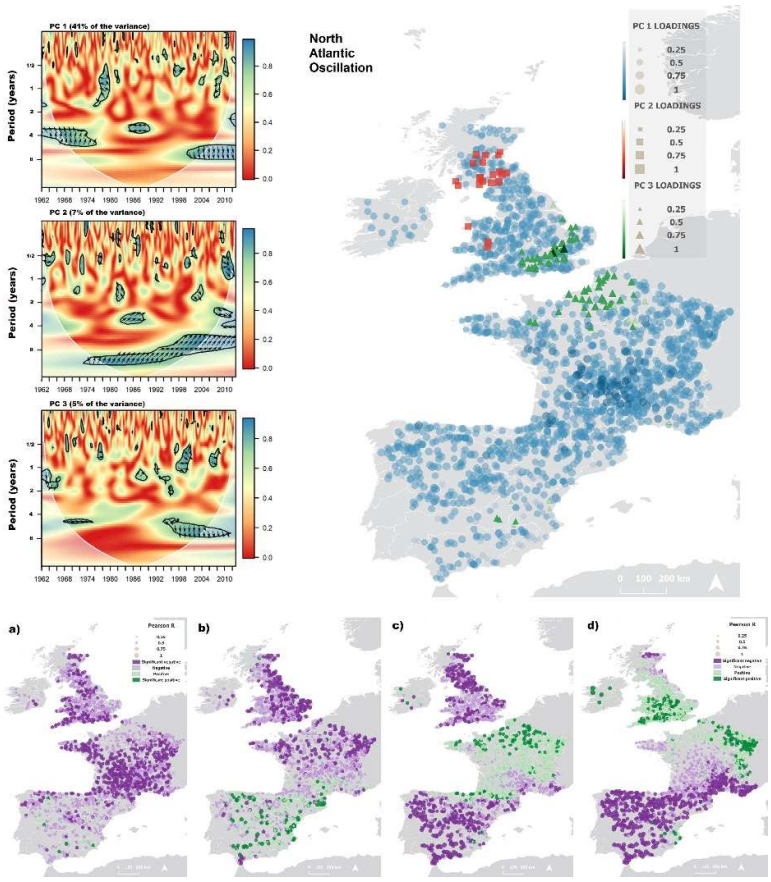
Scheme including the direct and indirect effects of enhanced aCO_2 on plant transpiration (E_t). E_s: soil evaporation, g_s: diffusive conductance of leaves, A: Photosynthesis, LAI: Leaf Area Index, AED: Atmospheric Evaporative Demand, LE: Latent Heat, SM: Soil moisture, VPD: Vapor Pressure Deficit, T: air Temperature, RH: Relative Humidity. Red lines represent positive influence on E_t. Blue lines represent a negative influence on E_t. Black lines represent climate fluxes and influences.

As CO2 concentration in the atmosphere rises, there is a need for improved physical understanding of its impact on global plant transpiration. This knowledge gap poses a major hurdle in robustly projecting changes in the global hydrologic cycle. For this reason, here we review the different processes by which atmospheric CO2 concentration affects plant transpiration, the several uncertainties related to the complex physiological and radiative processes involved, and the knowledge gaps which need to be filled in order to improve predictions of plant transpiration. Although there is a high degree of certainty that rising CO2 will impact plant transpiration, the exact nature of this impact remains unclear due to complex interactions between CO2 and climate, and key aspects of plant morphology and physiology. The interplay between these factors has substantial consequences not only for future climate and global vegetation, but also for water availability needed for sustaining the productivity of terrestrial ecosystems. Future changes in global plant transpiration in response to enhanced CO2 are expected to be driven by water availability, atmospheric evaporative demand, plant physiological processes, emergent plant disturbances related to increasing temperatures, and the modification of plant physiology and coverage. Considering the universal sensitivity of natural and agricultural systems to terrestrial water availability we argue that reliable future projections of transpiration is an issue of the highest priority, which can only be

achieved by integrating monitoring and modeling efforts to improve the representation of CO2 effects on plant transpiration in the next generation of earth system models.

Streamflow frequency changes across western Europe and interactions with North Atlantic Oscillation

Lorenzo Lacruz, J., Enrique Morán-Tejeda; Vicente-Serrano, S.M.; Jamie Hannaford; Celso García; Dhais Peña-Angulo; Conor Murphy. (2022) Streamflow frequency changes across western Europe and interactions with North Atlantic atmospheric circulation patterns. Global and Planetary Change (212) , 103797.



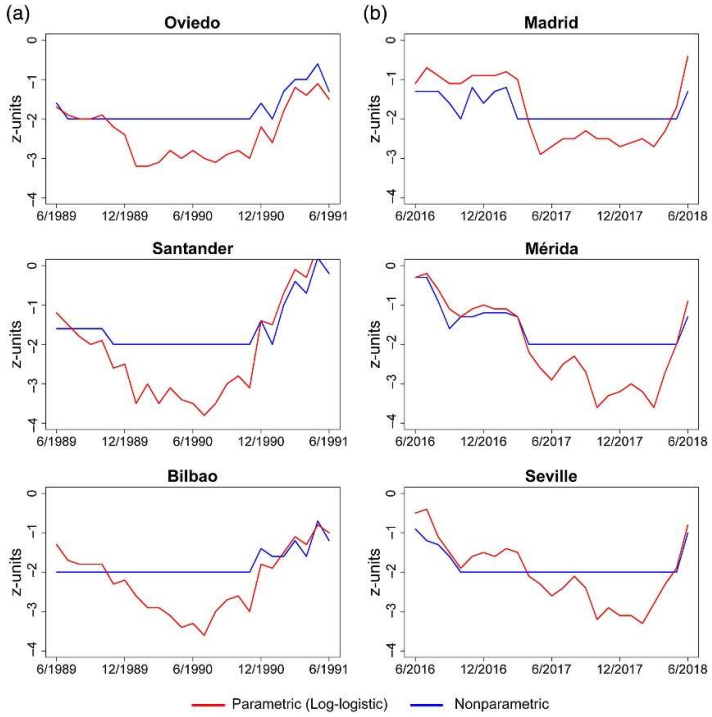
Summary of the influence of the NAO pattern on streamflow frequency changes across the study area. Left upper panels: Wavelet Coherence (WTC) power spectra between the NAO index and individual SSI series summarized by the three selected Principal Components. Right upper panel: spatial distribution of the loadings of the decomposed Wavelet Coherence scores between the SSI series and the NAO index. Lower panels: a) correlation coefficients between the NAO summer index and SSI series between 1962 and 1986; b) same between 1987 and 2012; c) correlation coefficients between the NAO winter index and SSI series between 1962 and 1986; d) same between 1987 and 2012.

This study identifies significant periodicities in streamflow dynamics across western Europe using a hydrological database encompassing 1874 monthly series from catchments in Ireland, the United Kingdom, France, Spain and Portugal, spanning the years 1962 to 2012. Significant and synchronous periodicities with the main atmospheric mechanisms over the North Atlantic sector are also identified using Cross Wavelet Transform and Wavelet Coherence analysis. Principal Components Analysis (PCA) were applied to the different Wavelet transforms analysis in order to summarize the results. These show the occurrence of a 7-years streamflow cycle in a large proportion of catchments within the study domain since the mid 1980's that was not present in earlier periods. The significance, intensity and persistence of the observed regional cycle follows a spatial gradient around the English Channel. We show how the transitive coupling of key atmospheric mechanisms is an

influencing factor causing the general change observed. These results suggest the occurrence of a regional change in the periodicities of streamflow across the western European domain. Our results emphasize the non-stationary interaction between streamflow and atmospheric circulation during recent decades and the prominent role of the North Atlantic Oscillation in the newly stablished streamflow cycles.

Assessment of parametric approaches to calculate the Evaporative Demand Drought Index

Noguera, I., Vicente-Serrano, S.M., Domínguez-Castro, F., Reig, F. (2022) Assessment of parametric approaches to calculate the Evaporative Demand Drought Index (EDDI). International Journal of Climatology. 42:834-849

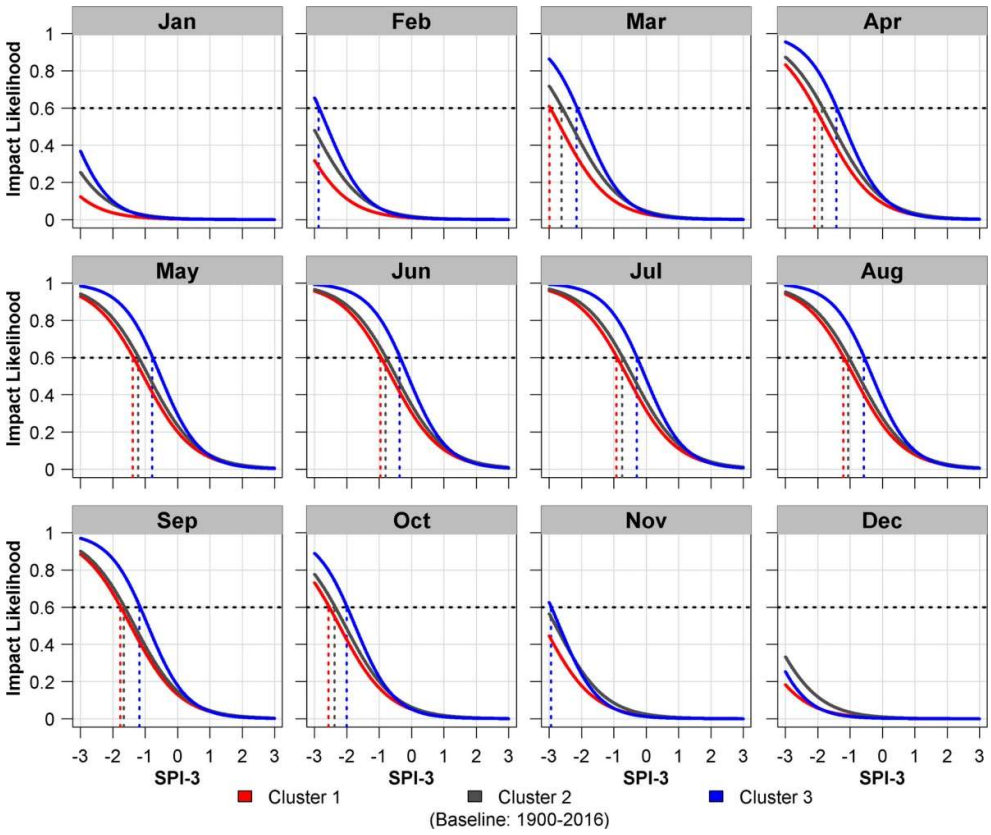


EDDI series during drought events of (a) 1990 (Oviedo, Santander and Bilbao) and (b) 2017 (Madrid, Mérida and Seville) at 12-month time scale, computed through a parametric and a nonparametric approach based on a reference period (1961–1989)

The Evaporative Demand Drought Index (EDDI), based on atmospheric evaporative demand, was proposed by Hobbins et al. (2016) to analyse and monitor drought. The EDDI uses a nonparametric approach in which empirically derived probabilities are converted to standardized values. This study evaluates the suitability of eight probability distributions to compute the EDDI at 1-, 3- and 12-month time scales, in order to provide more robust calculations. The results showed that the Log-logistic distribution is the best option for generating standardized values over very different climate conditions. Likewise, we contrasted this new parametric methodology to compute EDDI with the original nonparametric formulation. Our findings demonstrate the advantages of adopting a robust parametric approach based on the Log-logistic distribution for drought analysis, as opposed to the original nonparametric approach. The method proposed in this study enables effective implementation of EDDI in the characterization and monitoring of droughts.

Relating drought indices to cross sectoral impacts reported in newspaper articles

O'Connor, P., Murphy, C., Matthews, T. and Wilby, R.L. (2022) Relating drought indices to impacts reported in newspaper articles. International Journal of Climatology.Online Earlyview



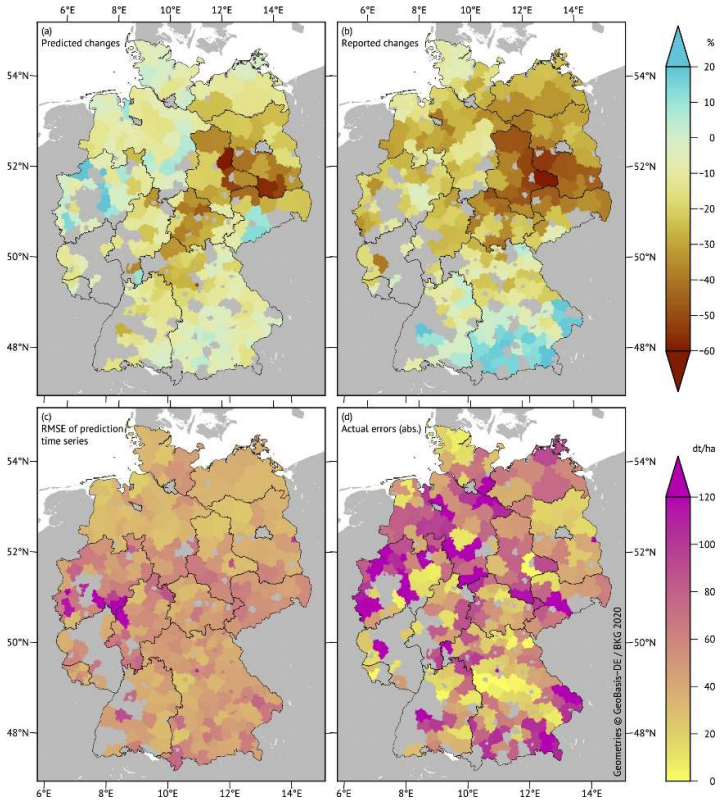
Predicted likelihood of reported impacts (monthly) from models generated using land-based impact articles and SPI-3 indices. Impact likelihoods for each cluster over the period 1900–2016 are shown for indices values ranging from −3 to 3. Indices values for each cluster resulting in a high reported impact likelihood (0.60) are also identified (dashed horizontal line)

Relating drought indicators and real-world impacts is fundamental for understanding and addressing drought vulnerability. We link drought indices and impacts from newspapers compiled in the Irish Drought Impacts Database (IDID) for the period 1900–2016. For three catchment clusters across the island of Ireland we link the Standardized Precipitation Index (SPI) with land-based impacts and the Standardized Streamflow Index (SSI) with water-based impacts by matching total reported articles per month with concurrent drought indices. Using logistic regression we find SPI-3 links best with land-based impact reports, whereas SSI-2 links best with water-based impact reports. Catchments in the east/southeast display the highest sensitivity to land- and water-based impacts; however, in summer months at low deficits northwestern catchments show a higher likelihood of impact reports. In winter months the likelihood of water-based impacts is considerably greater than the land-based equivalent, particularly in east/southeastern catchments. Moreover, the likelihood of news-worthy drought impacts has changed over the 117 year period. More severe deficits are required to induce a high likelihood (0.6) of land- and water-based impacts in east/southeastern and southwestern catchments during 1961–2016 compared with 1900–1960. Largest changes emerge in the southwest with SPI-3 values of −2.51 (<−3.00) required to reach the high impact likelihood threshold in the pre (post) 1961 period. Even greater reductions are found for water-based impacts in the southwest with SSI-2 values associated with high impact likelihoods changing from −2.04 to −2.58. Conversely, for catchments in the northwest more moderate drought deficits result in high impact likelihoods for both land-based (from <−3.00 to −2.32 SPI-3) and water-based

impacts (from <−3.00 to −2.29 SSI-2) for the 1961–2016 period. These findings show the value of newspaper archives for understanding regional sensitivities to drought plus their potential for underpinning a near real-time, drought monitoring and warning system in Ireland.

Predicting weather based crop yields in Germany

Conradt T (2022) Choosing multiple linear regressions for weather-based crop yield prediction with ABSOLUT v1.2 applied to the districts of Germany. Int J Biometeorol 66(11), 2287–2300.



Spatial characteristics of the silage maize yield prediction for the drought year 2018. a Predicted yield changes compared to the average district yields of the years 2012–2017. b Observed changes according to the official statistics. c Root-mean-square errors (RMSE) of all out-of-sample district yield predictions for the years 1999–2020. d Absolute values of prediction errors for 2018. a and b show relative deviations in percent (upper scale), c and d refer to absolute deviations in dt ha−1 (lower scale)

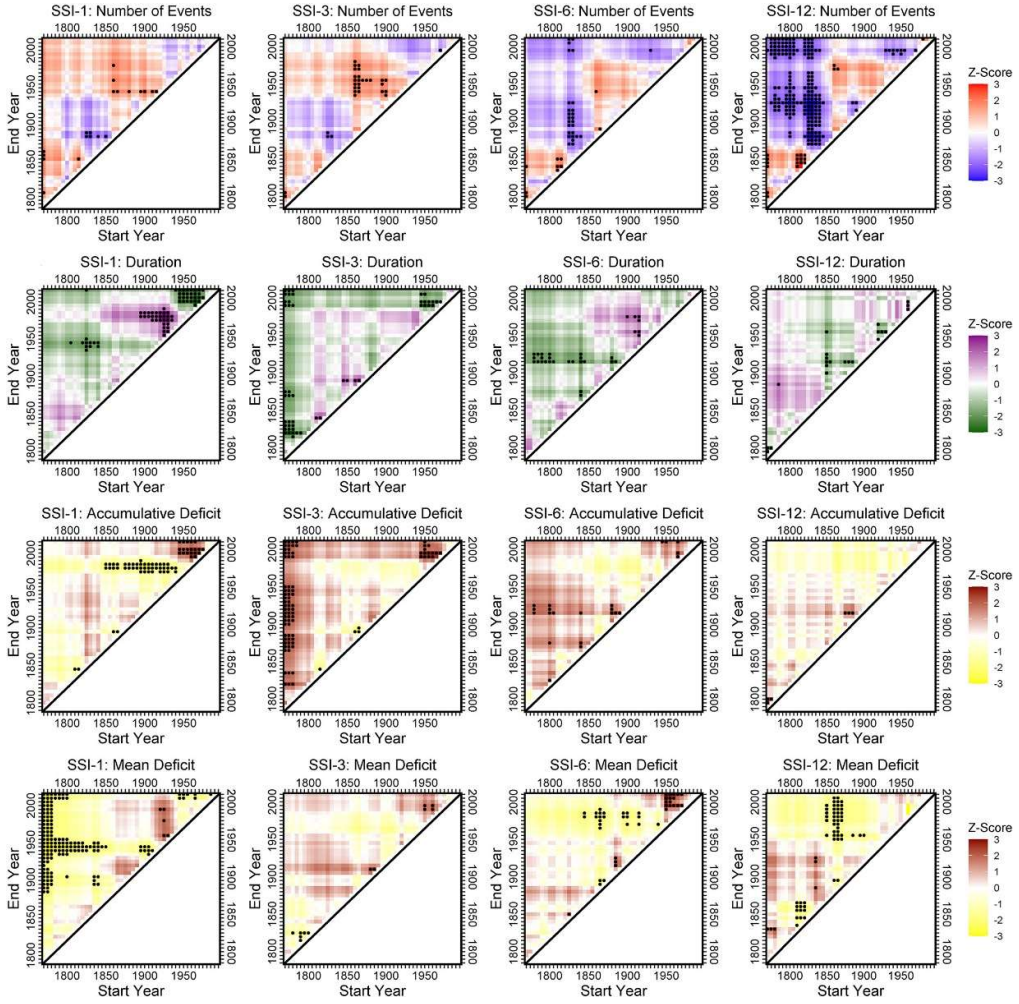
ABSOLUT v1.2 is an adaptive algorithm that uses correlations between time-aggregated weather variables and crop yields for yield prediction. In contrast to conventional regression-based yield prediction methods, a very broad range of possible input features and their combinations are exhaustively tested for maximum explanatory power. Weather variables such as temperature, precipitation, and sunshine duration are aggregated over different seasonal time periods preceding the harvest to 45 potential input features per original variable. In a first step, this large set of features is reduced to those aggregates very probably holding explanatory power for observed yields. The second, computationally demanding step evaluates predictions for all districts with all of their possible combinations. Step three selects those combinations of weather features that showed the highest predictive power

across districts. Finally, the district-specific best performing regressions among these are used for actual prediction, and the results are spatially aggregated. To evaluate the new approach, ABSOLUT v1.2 is applied to predict the yields of silage maize, winter wheat, and other major crops in Germany based on two decades of data from about 300 districts. It turned out to be absolutely crucial to not only make out-of-sample predictions (solely based on data excluding the target year to predict) but to also consequently separate training and testing years in the process of feature selection. Otherwise, the prediction accuracy would be over-estimated by far. The question arises whether performances claimed for other statistical modelling examples are often upward-biased through input variable selection disregarding the out-of-sample principle.

Historical droughts in Irish catchments 1767-2016

O'Connor, P., Murphy, C., Matthews, T. and Wilby, R.L. (2022) Historical droughts in Irish catchments 1767–2016. International Journal of Climatology,* 42*(11), 5442-5466.

Recent prolonged dry periods in summer 2018 and spring 2020 have reawakened interest in drought in Ireland, prompting questions regarding historical drought occurrence and potential long-term risks. Employing 250 years of monthly precipitation and flow reconstructions, we investigate historical drought in Irish catchments evaluating the characteristics (number of events, duration, and deficits) of moderate, severe, and extreme droughts as well as the propagation of meteorological to hydrological drought. Using standardized indices, we identify three distinct catchment types. Cluster 1 catchments, located in the wetter northwest are characterized by small areas, low groundwater storage, and the highest frequency of hydrological drought relative to other catchments. Cluster 3 catchments, located in the drier east and southeast have larger areas, greater groundwater storage, the highest frequency of meteorological drought but the least hydrological droughts. However, once established, droughts in Cluster 3 tend to be more persistent with large accumulated deficits. Cluster 2 catchments, located in the southwest and west, are intermediate to Clusters 1 and 3, with hydrological droughts typically of shorter durations, reduced accumulated deficits but greater mean deficits. The most extreme droughts based on accumulated deficits across all catchments occurred in 1803–1806, 1854–1859, 1933–1935, 1944–1945, 1953–1954, and 1975–1977. Although not as severe, droughts in 1887–1888, 1891–1894, and 1971–1974 also appear as significant extremes. Changes in drought characteristics reveal a complex picture with the direction, magnitude, and significance of trends dependent on the accumulation period used to define drought, the period of record analysed, and the reference period used to standardize indices. Of particular note is a tendency towards shorter, more intense meteorological and hydrological droughts. Our findings offer important insight for drought and water management in Ireland given the paucity of extreme droughts in short observed river flow records.



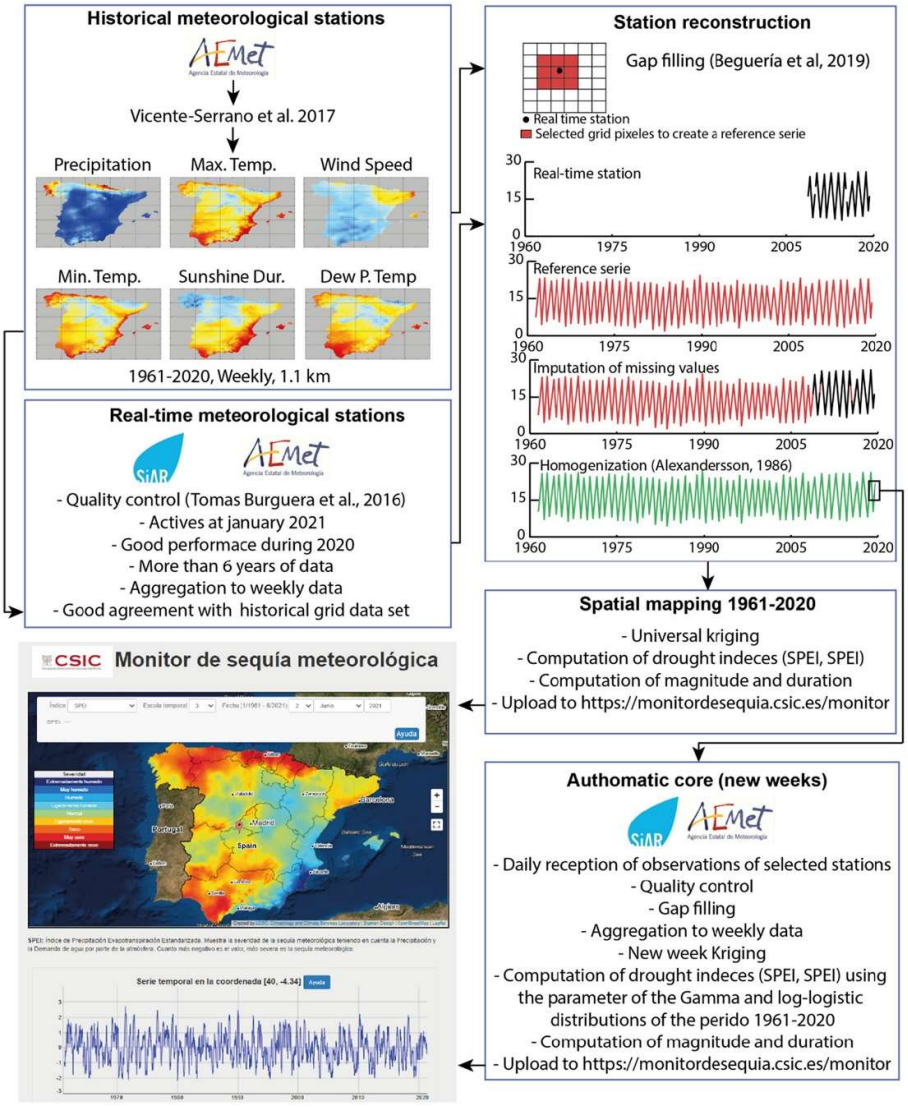
MK Zs scores for trends in the number of events, durations, accumulated and mean deficits of moderate hydrological droughts for varying start and end dates. Results are displayed for median reconstructions across all catchments with SSI values, derived from the Tweedie distribution and 1930–1999 reference period. MK Zs values are calculated for periods ranging from 30 to 245 years in 5 year increments for accumulation periods of 1, 3, 6, and 12 months. Black dots indicate test periods for which trends are significant at the 0.05 level

A near real-time drought monitoring system for Spain

Vicente-Serrano, S.M., Domínguez-Castro, F., Reig, F, Beguería, S., Tomas-Burguera, M., Latorre, B., Peña-Angulo, D., Noguera, I., Rabanaque, I., Luna, Y., Morata, A., El Kenawy, A. (2022) A near real-time drought monitoring system for Spain using automatic weather station network. Atmospheric Research 271, 106095.

Drought monitoring is essential to determine, at short time intervals, the main characteristics of drought events, such as their duration, severity, and spatial distribution. To ensure that drought monitoring represents a useful tool for governmental plans aimed at preventing or minimizing drought impacts, up-to-date information must be instantaneously accessible and it must provide high spatial and temporal resolution. This study presents a system that allows the automatic tracking of meteorological droughts in the Spanish territory, based on an open and easy-to-use online platform (https://monitordesequia.csic.es/monitor). This drought monitoring system provides two drought synthetic indices: the Standardised Precipitation Index (SPI) and the Standardised Precipitation Evapotranspiration Index (SPEI). Information is provided on a quasi-weekly basis, in a grid format, with a spatial resolution of 1.1*1.1 km, and with data from 1961 to the present time. This drought monitor is

updated based on the real-time information gathered from automatic stations, which in turn requires historic information to identify and track drought events. The drought indices are obtained from data processing (quality control, temporal series reconstruction, homogenisation, interpolation, and validation) using climatic variables (maximum and minimum temperatures, solar radiation, rainfall, dew point, and wind speed) which are provided by the Spanish Meteorology Agency and the Ministry of Agriculture of the Spanish Government. We performed a validation of the drought indices for the whole historical period (1961–2020). This allowed us to observe a strong spatial agreement between the indices obtained with the historical dataset and the indices from the monitoring dataset, especially for mainland Spain and the Balearic Islands (Pearson's r, SPI and SPEI >0.99). The presented real-time drought monitoring system represents a relevant and useful tool that allows for quick and effective actions to prevent and mitigate the effects of drought on society and ecosystems.



Summary of the procedure for developing the drought monitoring system.

Stakeholder engagement and media communication

The CROSSDRO project aims to develop practical guidance for future planning through the strong engagement of drought-sensitive stakeholders. While the Covid-19 pandemic has disrupted stakeholder engagement to some extent, there has been considerable work completed. Below is a flavour of our key achievements in these areas for 2022.

Field visits to local farms in Moldova to disseminate CROSSDRO findings



Farm visits to farmers in different districts of Moldova discussing the problems of soil health and resilience to droughts. In the farm "Gospodarul Rediu", Falesti district, where the farm manager is Mr.Kiktenco Nicolai highlighted that there are good possibilities to see real measures and results in promoting conservation agriculture system. The guests from USAS, from Colorado State University could also see the real opportunities for improving soil quality, allowing the transition to a more sustainable farming system. During this and other visits to the farm we have demonstrated the advantages of No-till sowing of winter cereal crops in reducing the production expenses together with improving the quality of the environment.

18 seminars for farmers at Selectia Research Institute of Field Crops


Seminars aimed at communicating the best agricultural practices that have been demonstrated to increase yields and simultaneously prevent soil degradation, water pollution, and maintain biodiversity at the farm and landscape level. Farmers could see the influence of different farming practices on the health of the roots grown in in crop rotations and in permanent cropping as well as soil compaction under the influence of different systems of soil tillage and fertilization in the crop rotations and in permanent cropping. They also become acquainted with the new varieties and hybrids for different crops with high yield potential, tolerance to droughts, pests and diseases, with high capacity to suppress weeds.

Advancing Moldova's National Climate Change Adaptation Planning

On 25th November,2022 a National Conference was organized under the auspices of her excellency the President of the Republic of Moldova Maia Sandu titled “Advancing Moldova's National Climate Change Adaptation Planning”. A report was presented at the conference by Prof.Boris Boincean:"Sustainable and climate-smart management of Chernozem soils in Moldova". Simultaneously a brochure was prepared under the title: "Nature -based solutions in adaptation to climate change" Prof. Boincean was nominated as the national consultant for the development of knowledge products in agriculture management and ecosystem services. Participants discussed the issues related to potential decrease in crop yields and adaptation to climate change, in particular to more frequent droughts. The crucial role of soil health was emphasized in providing ecosystem and social services. The causes of soil health deterioration were evaluated and the "Soil Resolution" was offered as the policy document to be promoted by the Parliament of the Republic of Moldova.

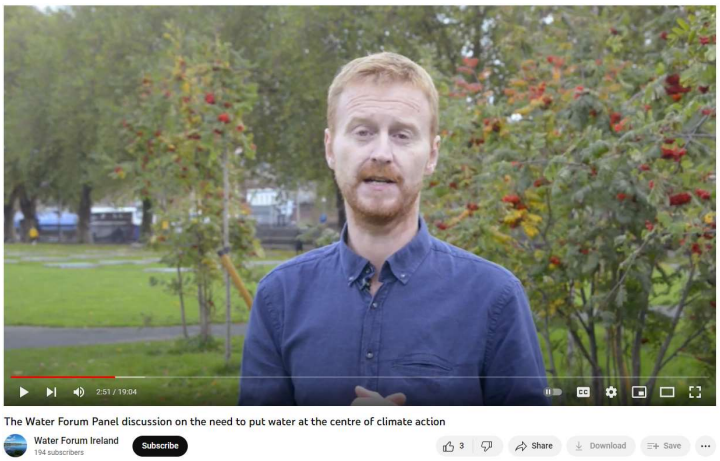
Prof. Boincean engages media on climate change impacts and adaptation for crops

On 8 September,2022,correspondents from 8 TV and Radio companies from Moldova and the European Community met at Selectia Research Institute of Field Crops to discuss the scientific achievements of the institute in decreasing the negative influence of global warming. Prof.Boris Boincean discussed the importance of using non-GMO locally produced seeds and breed varieties and hybrids for different field crops. The importance of sustainable and resilient soil management systems were emphasized, which reduce the negative impact of global warming and soil erosion from extreme weather conditions.

Prof. Vicente-Serrano on CNN Chile to discuss drought

https://www.youtube.com/watch?v=47f8RFfqIHo

Prof. Conor Murphy highlights the need to put water at the centre of climate action as part of Ireland's national Science Week.



https://www.youtube.com/watch?v=kSmZUs_Z8ig

https://thewaterforum.ie/science-week-panel-discussion-on-the-need-to-put-water-at-the-centre-of-climate-action/

The lack of rain and the decrease of reservoir water increase the fear of drought in Spain

https://www.lavanguardia.com/vida/20220208/8040323/temperatura-enero-consolida-tendencia-inviernos-vez-mas-calidos.html

In Spain it does not rain less, but the temperatures are getting warmer

https://www.csic.es/es/actualidad-del-csic/sergio-vicente-en-espana-no-llueve-menos-pero-las-temperaturas-son-cada-vez-mas

Is it possible to predict a drought? These Spanish scientists try

https://www.elconfidencial.com/tecnologia/ciencia/2022-02-25/prevision-sequia-espana-falta-lluvias_3379047/

La Niña hits half the world and fuels drought in Spain

https://www.abc.es/sociedad/abci-nina-golpea-medio-mundo-y-alimenta-sequia-espana-202202280024_noticia.html?ref=https%3A%2F%2Fwww.abc.es%2Fsociedad%2Fabci-nina-golpea-medio-mundo-y-alimenta-sequia-espana-202202280024_noticia.html

What will happen if we continue without rain and the drought continues?

https://www.ondacero.es/programas/julia-en-la-onda/audios-podcast/entrevistas/que-sucedera-seguimos-lluvias-continua-sequia_20220301621e578de2af800001dc75d9.html

A lethal avalanche and a historic drought: climate change hits northern Italy

https://elpais.com/clima-y-medio-ambiente/2022-07-06/un-alud-letal-y-una-historica-sequia-el-cambio-climatico-castiga-al-norte-de-italia.html

Reduce water in the city? It will be one of the largest droughts in a hundred years.

https://www.diariodepontevedra.es/articulo/pontevedra/reducir-agua-ciudad-sera-sequias-mas-grandes-cien-anos/20220801123407121235 1.html

The priority is always to maintain the urban water supply

https://www.laverdad.es/sociedad/prioridad-siempre-mantener-20220812135815-ntrc.html

A CSIC researcher reveals how water will be distributed in the droughts of the future

https://www.cope.es/programas/la-linterna/noticias/investigador-del-csic-desvela-como-repartira-agua-las-sequias-del-futuro-20221005_2327653

"The prospects for the future are not very good": a CSIC expert explains what we can do to alleviate the effects of drought

https://cadenaser.com/nacional/2022/11/22/las-perspectivas-para-el-futuro-no-son-muy-buenas-un-experto-del-csic-explica-que-podemos-hacer-para-paliar-los-efectos-de-la-sequia-cadena-ser/

Podcast: Drought and its cycles

https://programaagroconciencia.blogspot.com/2022/11/sequia-ciclos.html

Is this winter our fault?

https://www.elcorreo.com/sociedad/invierno-culpa-20230108100701-ntrc.html

What does climate change mean for Irish rivers?

https://www.rte.ie/brainstorm/2022/0519/1299872-irish-rivers-climate-change/

The subtle danger climate change poses to 'highly vulnerable' Ireland

https://www.irishtimes.com/environment/climate-crisis/2022/11/10/the-subtle-danger-climate-change-poses-to-ireland/

Collaboration and engagement with other drought related projects

Our research on CROSSDRO is highly collaborative and in 2022 we have been engaging and working with other European and nationally funded projects related to drought. Below is a list of projects that we have had sustained engaged with.

- Red española e iberoamericana sobre variabilidad climática y servicios climáticos en ecosistemas terrestres y marinos. LINCGLOBAL-CSIC.
- Mechanisms of hydrological drought variability across Europe (MEHYDRO). i-LINK CSIC.
- Mid-mountain adaptation to climate change - LIFE MIDMACC, LIFE18 CCA/ES/001099. LIFE Programme EU
- Riesgo de eventos meteorológicos e hidrológicos extremos en España: impactos, escenarios futuros y herramientas para mejorar la resiliencia y adaptación al cambio climático (EXMERISK). Ministry of Science and Innovation. Spain
- Evaluación a largo plazo de los cambios en la CUbierta vegetal en los parques nacionales españoles y su conexión con los procesos de VAriabilidad y cambio CLImático. Spanish Ministry for the Ecological Transition-Spanish Organism of National Parks.
- Development of methodology for complex monitoring and prediction of drought and fire weather conditions in Ukraine. UCRAN-CSIC.
- Irish Droughts: Environmental and Cultural Memories of a Neglected Hazard. Interdisciplinary Project funded by the Irish Research Council (IRC) Coalesce Scheme.
- HydroPredict: Ensemble Riverflow Scenarios for Climate Change Adaptation. Funded by the Irish Environmental Protection Agency
- WaterFutures: WFD Future Scenarios and Management Tools. Funded by the Irish Environmental Protection Agency

Presentations at international conferences

Vicente-Serrano, S.M. The complex multi-sectorial impacts of drought in the Spanish Pyrenees. In Extreme events in the atmosphere and the ocean. 14 March 2022. Lisboa. On-line.

Iván Noguera, Fernando Domínguez-Castro, and Sergio M. Vicente-Serrano How does the rise of atmospheric water demand affect flash drought development in Spain? EGU 2022.

Vicente-Serrano, S.M. Near real time drought monitoring in Spain using automatic weather station data. Network of Drought Observatories in the EU. Ispra (Italy) 16-17 Junio 2022

Vicente-Serrano, S.M., Javier Zabalza, Iván Noguera, Dhais Peña-Angulo, Carmelo Juez, Conor Murphy, Fernando Domínguez-Castro, Lars Eklundh, Hongxiao Jin, Tobias Conradt, Jorge Lorenzo-Lacruz, Ahmed El Kenawy. Cross-interactions of ecological and hydrological droughts in the central Spanish Pyrenees. 7th IAHR Europe Congress, September 7th – 9th, 2022, Athens, Greece.

Contact us

Project website: https://crossdro.csic.es/

Project coordinator: Sergio M. Vicente-Serrano, Instituto Pirenaico de Ecología, Consejo Superior de Investigaciones Científicas

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CROSSDRO

ANNUAL NEWSLETTER

Research partners:

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No. 2 - December 2021

What is CROSSDRO?

CROSSDRO (*CROSS-sectoral impact assessment of DROughts in complex European basins*) is a EU JPI Climate project that runs from September 2019 to March 2023.

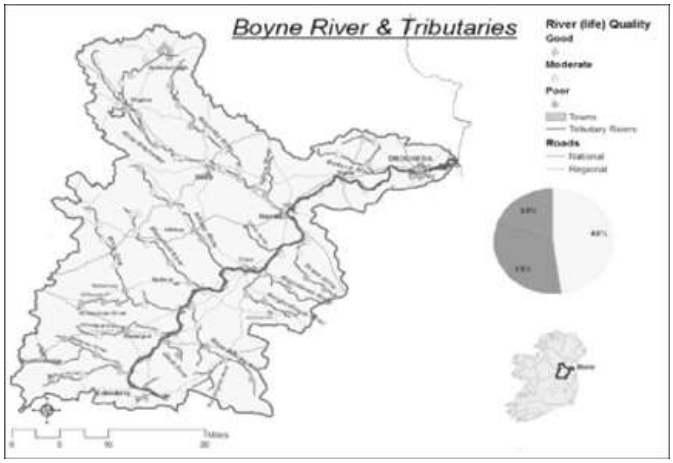
Where is the research taking place?

CROSSDRO is analysing drought in four European basins with very different socio-ecological contexts. Case study sites include:

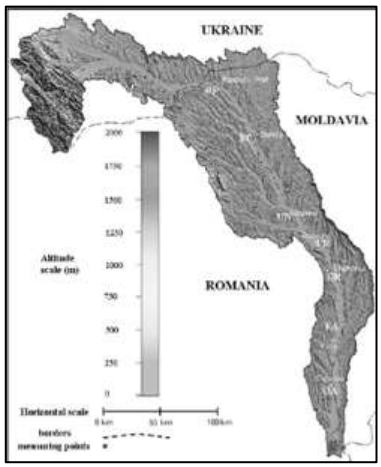
i) the upper Aragon basin in Northeast Spain,

ii) the German part of the Elbe basin,

iii) the Boyne basin in Ireland.



iv) the Moldovan part of Prut basin.



What are the project objectives?

The CROSSDRO objectives are to:

- Better understand the multi- and cross-sectoral impact of droughts including the connection between physical and socioeconomic impacts and pathways.
- Better understand stakeholder needs and perceptions of drought.
- Examine drought impact across scales – catchment to European scale, and both historically and into the future.

Who is involved?

CROSSDRO brings together scientists from five research institutions. The leading institution is the Spanish National Research Council, and the project coordinator is Sergio Vicente-Serrano. Partner institutions are University of Maynooth in Ireland (group leader C. Murphy), Lund University in Sweden (group leader L. Eklundh), Research Institute of Field Crops "Selectia" in Moldova (group leader B. Boincean) and Potsdam Institute for Climate Impact Research in Germany (group leader T. Conradt).

Progress so far…

We are now two years into the project and would like to provide an update on the latest developments, project milestones and lessons learned over the last 12 months (see Newsletter No 1 for 2020 update).

Stakeholder events

The CROSSDRO project aims to develop practical guidance for future planning through the strong engagement of drought-sensitive stakeholders in each basin. While the Covid-19 pandemic has disrupted stakeholder engagement to some extent, there has been engagement events, surveys and in-depth interviews conducted across the four basins.

Aragon basin, Spain

There have not been opportunities for engagement or capacity building events this year in the basin as stakeholders and authorities are occupied in developing a new drought plan.

Elbe basin, Germany

Stakeholder activities were still largely hampered by the pandemic situation. On 21 October 2021 Tobias Conradt represented CROSSDRO in an expert hearing about high end climate change (i.e. end-of-century conditions under the pessimistic RCP 8.5 emission scenario) consequences for Germany. This was a four-hours virtual meeting with about 20 participants from German research institutions and ministries, organized by the Berlin-based Adelphi company and another of PIK's departments, with a break-out group focusing on drought effects in agriculture and forestry. For 30 November, Tobias Conradt was invited by a Bavarian producer of agricultural soil cultivation machinery (Horsch Maschinen GmbH, Schwandorf) to a panel discussion about future yield expectations and climate-change related pressures on agricultural production. The German-language talk was video-streamed live on the Internet.

Boyne basin, Ireland

Stakeholder engagement and outreach in the Boyne basin has been ongoing. Lessons and insights from the project were disseminated nationally in Ireland via an invited presentation to a technical workshop on droughts organised by the Irish group of the International Association of Hydrogeologists (IAH). At the event Prof. Murphy outlined findings from the European and national scale from CROSSDRO to inform current and future thinking about drought on the island. Engagement with other national drought projects also took place to ensure sharing of insight and knowledge to be

benefit of all parties. Of note are ongoing interactions with the Irish Research Council funded project 'Forgotten droughts: Cultural memories of a neglected hazard in Ireland'. This project offers insight into the cultural and historical impacts of drought in Ireland with sharing of information around the Boyne basin and the impacts of historical drought ongoing. Prof. Murphy has also had the opportunity to discuss drought and management plans with Irish Water, the national water management agency to ensure that results from the project clearly communicated to this important stakeholder and that their needs for more effective drought management are taken onboard by the project.

Prut basin, Republic of Moldova

Selectia Research Institute of Field Crops (Moldova) has organized many events in 2021 dedicated to sustainable and resilient soil and crop management in the conditions of extreme weather conditions. This included 24 seminars with agricultural producers in different districts of Moldova and 6 scientific-practical conferences with the national and international participation. Simultaneously the work of the institute was reflected in 22 reports on the national radio and 23 reports on national TV.

Field trials with different varieties of winter wheat, winter barley, peas, soybeans have been visited by farmers of Moldova. Long-term field experiments with different crop rotations, systems of soil tillage and soil fertilization have been visited by both local producers as well as official representatives from the Government of Moldova.

The director of Selectia Research Institute of Field Crops has participated with two public lectures at the Academy of Sciences of Moldova on topics related to sustainable management of Chernozem soils in the conditions of global warming and the restoration of seed production in Moldova. These topics are very important especially in the pandemic situation for providing food security of the country.

Scientific outputs

Boyne Basin, Ireland

We have conducted stakeholder interviews with Boyne and national-level stakeholders to better understand sectoral sensitivities and understandings of drought, past drought experiences and challenges, and concerns about future drought events. We approached target interviewees in January 2021 and conducted interviews between February and July 2021. We interviewed 40 individuals who can be broadly divided into three groups: individuals with a direct interest in drought from a livelihood perspective; individuals with a direct interest in drought from a recreational or general perspective; and those with an indirect professional interest. Interview findings indicate that drought impacts in the Boyne (and Ireland more broadly) are understood and experienced from diverse perspectives (e.g. water supplies, freshwater systems, agriculture, forestry, ecology, fire risk, landslides).

Streamflow database generated for Europe and hydrological droughts analysed

The **Instituto Pirenaico de Ecología (IPE-CSIC)** in the frame of the project CROSSDRO has developed a dataset of streamflow series covering the entire European continent. The dataset contains more than 3200 series, which cover the period 1962-2017. The series have been quality controlled and reconstructed to avoid the existence of data gaps. This information is available at https://msed.csic.es/

Figure 1. *Web server of the European hydrological database.*

This hydrological information is being used to analyse the evolution of hydrological droughts in the region and to determine the strong complexity and spatially diverse patterns across Europe. The results show a positive trend towards more frequent and severe droughts in Southern and Eastern Europe and conversely a negative trend over Northern Europe. This emphasizes that hydrological droughts have shown complex spatial patterns across Europe over the past six decades, implying that hydrological drought behaviour in Europe has a regional character.

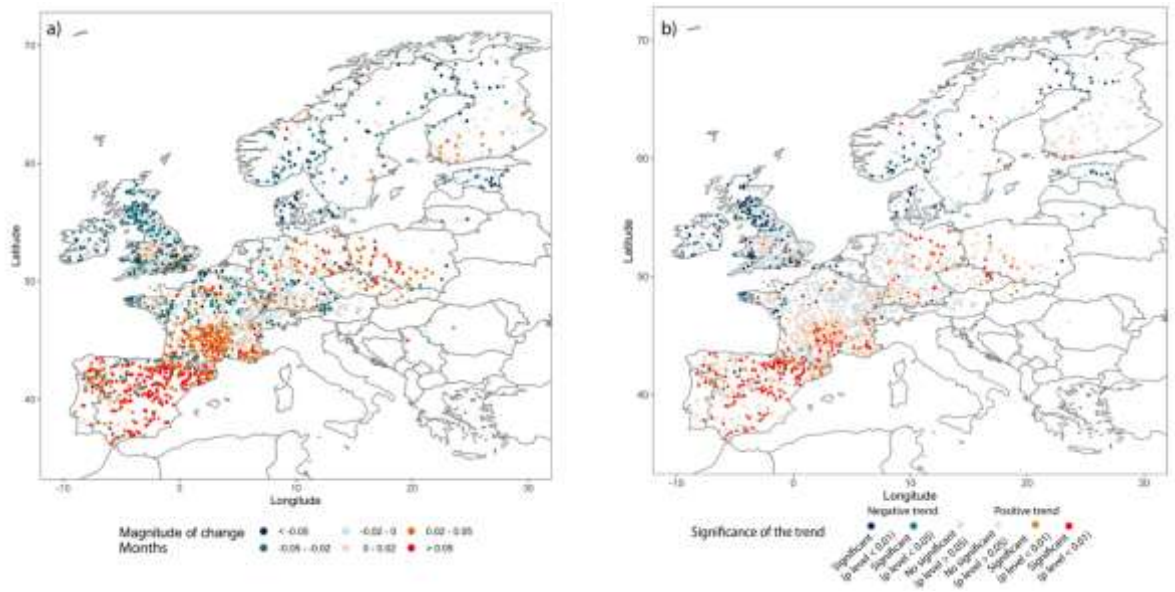


Figure 2. *Trends in the duration of drought events from 1962 to 2017. (a) Spatial distribution of the magnitude of change in SSI and (b) the corresponding significance of trends (at $p < 0.05$, $p < 0.01$) over the same period. Each circle represents one gauging station.*

The response of hydrological droughts to vegetation changes in the Aragon basin in the central Spanish Pyrenees

The CROSSDRO project has published an article in Geophysical Research Letters demonstrating that increased vegetation in mountainous headwaters amplifies water stress during dry periods. The dynamics of blue and green water partitioning under vegetation and climate change, as well as their different interactions during wet and dry periods, are poorly understood in the literature. For this reason, we analysed the impact of vegetation changes on blue water generation in a central Spanish Pyrenees basin undergoing intense afforestation. We found that vegetation change is a key driver of large decreases in blue water availability. The effect of vegetation increase is amplified during dry years, and mainly during the dry season, with streamflow reductions of more than 50%. This pattern can be attributed primarily to increased plant water consumption. Our findings highlight the importance of vegetation changes in reinforcing the decrease in water resource availability. With aridity expected to rise in southern Europe over the next few decades, interactions between climate and land management practices appear to be amplifying future hydrological drought risk in the region. The key points of the study are: i) Forest secondary succession is the main driver of streamflow trends in mountain Mediterranean areas, ii) The effects of vegetation changes on water availability strongly differ between dry and humid periods, iii) Trends in streamflow in response to vegetation changes are mostly recorded during the dry and warm season. The article is available at: https://doi.org/10.1029/2021GL094672

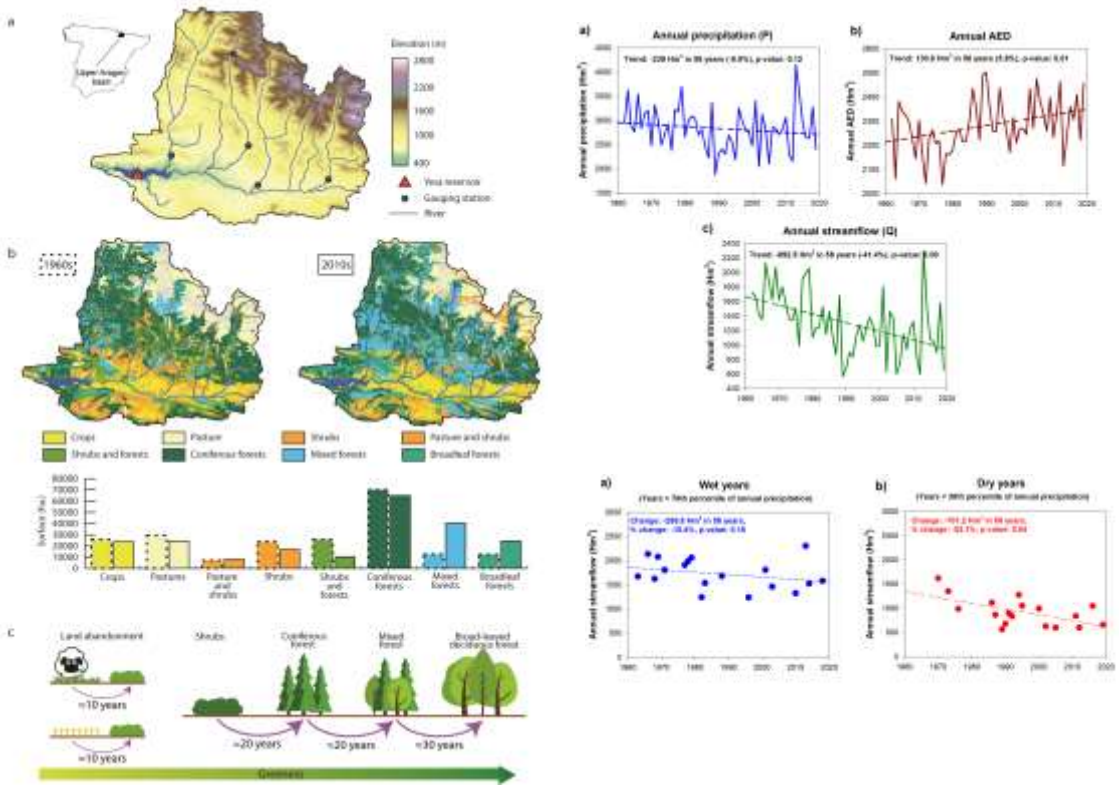


Figure 3. *Land cover changes in the Aragon catchment (left), evolution of precipitation, streamflow and the atmospheric evaporative demand (top right), and the response of streamflow to dry and humid years (bottom right).*

Prut Basin, Moldova

Sensitivity of crop yields in Moldova increases in response to global warming

80% of the Republic of Moldova is covered by non-irrigated crops, with the agriculture sector employing more than 30% of country's population. This region has been frequently affected by droughts, with large negative consequences on crop yields. The year 2020 was particularly serious since crop yields reduced by 30% on average, reducing employed people in the sector to 20%, which contributed to an 8% decline in Gross Domestic Product (GDP). For these reasons, CROSSDRO project has analysed in depth the relationship between crop yields and drought severity under a scenario of global warming in the Republic of Moldova. We have showed that the vulnerability of crop yields to precipitation variability has noticeably increased during the last twenty years related to the strong temperature increase recorded in the region. Climate change projections suggest a reinforcement of limiting climate conditions for adequate crop yield. For this reason, it is necessary to promote more conservative land management practices, characterized by perennial spring crops and winter cereals, to increase the stock of soil moisture and vineyards that may adapt to more arid and warmer climate conditions, maintaining productivity and grape quality. Crop adaptive measures are then essential to guarantee an adequate yield in crops in a region in which agriculture has a very important role in the country's economy.

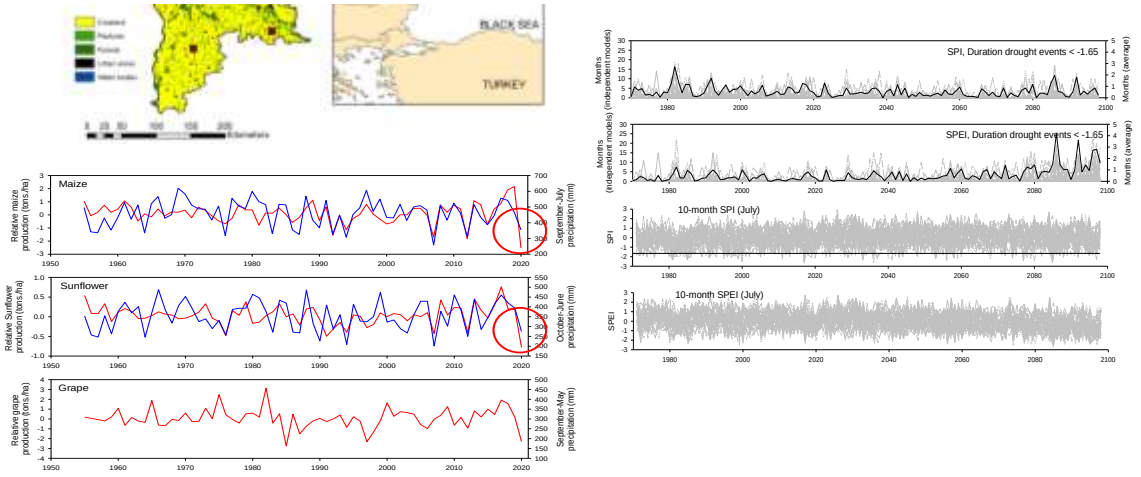


Figure 4. *Land cover map of Moldova (top left), Evolution of the temporal variability of precipitation during the period of higher correlation with the anomalies in crop yield (top right) and the annual yields of the three crops and evolution of the drought duration from 43 climate change models in Moldova using the SPI and the SPEI (bottom left). Gray lines show the evolution for each model and black lines represent the average. Two bottom plots show the evolution of the SPI and SPEI at the time scale of 10 months in July. Horizontal black lines represent SPI and SPEI values equal to -1.65.*

Elbe Basin, Germany

The impacts of the 2018–2019 drought over Central Europe

The Potsdam Institute for Climate Impact Research (PIK) assessed drought impacts for the German Elbe River basin (97 175 km², including the cities of Hamburg, Berlin, and Dresden). According to the meteorological drought indices for the region, this event was the most extreme drought in the last six decades, with some literature suggesting you would have to go back to the year 1540 to find a comparable event in Germany.

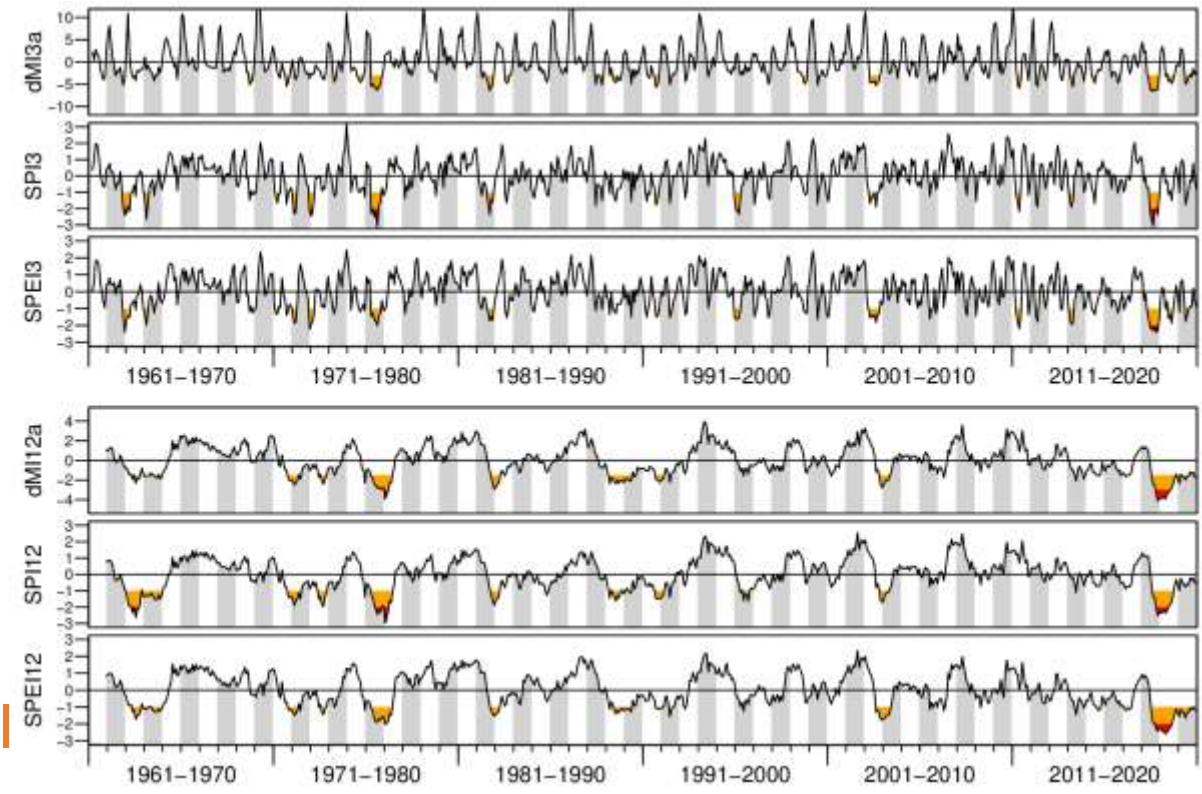


Figure 5. *Drought indices calculated from meteorological averages over the German part of the Elbe River basin (weather data provided by DWD, the German Weather Service). Red colour indicates extreme drought. The acronyms refer to de Martonne's index (dMI), describing compound anomalies of precipitation and temperature, the WMO-recommended Standardized Precipitation Index (SPI) based on seasonal precipitation frequency distributions, and the Standardized Precipitation Evaporation Index (SPEI) which also takes evaporation into account. The numbers refer to the two different time windows applied (3 and 12 months).*

The most prominent effect was a breakdown of agricultural yield levels in the region. Average yields of the six pre-drought years (2012–2017) dropped by 20–40 % in 2018, with maize, potatoes, sugar beets and fodder plants most affected. In the most affected districts, much higher losses were reported, and some farmers had to face total harvest failures. Animal production remained however quite stable, but additional fodder had to be imported or bought from less drought-affected parts of the country. This is reflected in the animal producer prices which rose in 2019, the second drought year, up to 17.8 % over the 2018 level and went back to that level not before November 2020. Forestry was also affected by drought-related damages: Wood harvests were driven up by windstorms and bark beetle attacs (which especially hit already drought-affected spruce stands).

Nevertheless, immediate economic drought consequences seem limited to Agriculture and Forestry which make up only one percent of the regional economy, calculated by gross value added (GVA). In contrast to the financial crisis of 2008–2009 and the pandemic kicking in in 2020, no drought- or heat-related dents are visible in the regional economic time series.

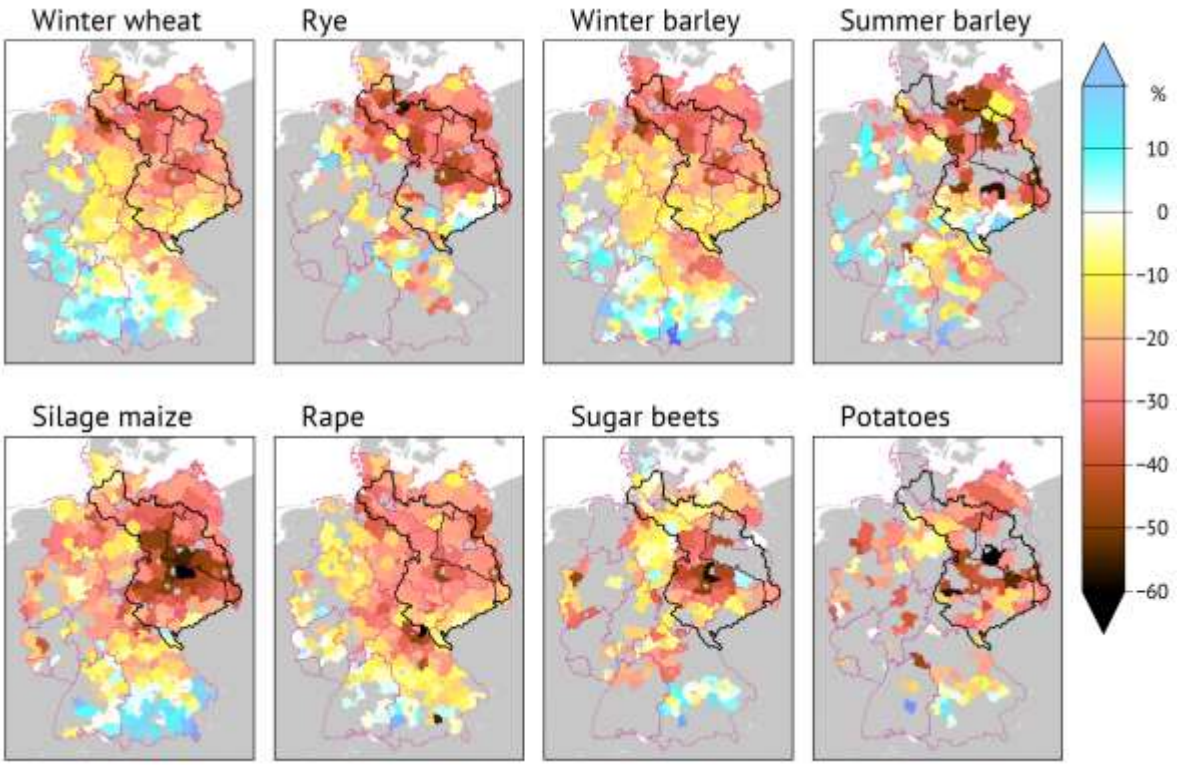


Figure 6. *Crop yields of 2018 relative to the 2012–2017 averages in German district-level administrative units; grey areas indicate missing data. The areas of the German Elbe River basin (and the Havel River tributary) are outlined in black. Data source: Statistische Ämter des Bundes und der Länder [statistical offices of the federation and the federal states], Map geometries © 2018 GeoBasis-DE/BKG (VG1000, 2018).*

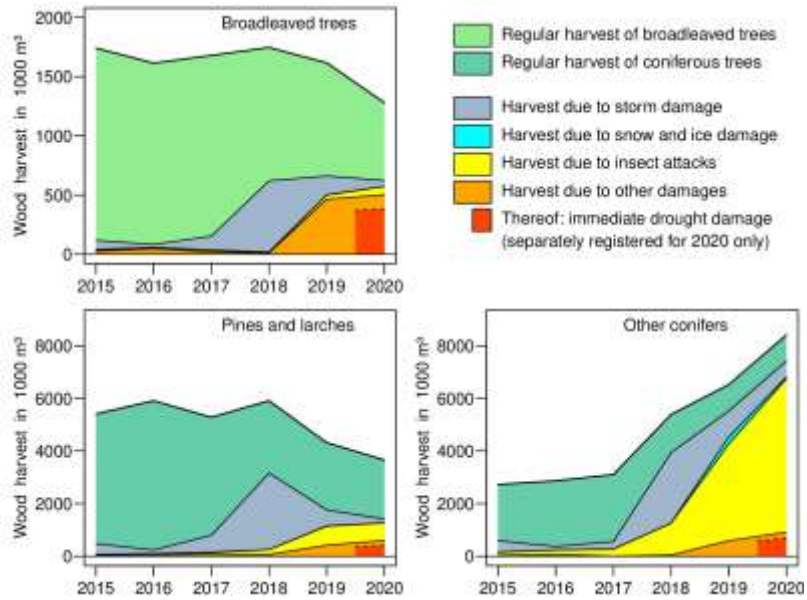


Figure 7. Wood harvests in forests of five federal states approximately covering the German Elbe River basin. Data source: Statistisches Bundesamt [federal statistical office], Wiesbaden.

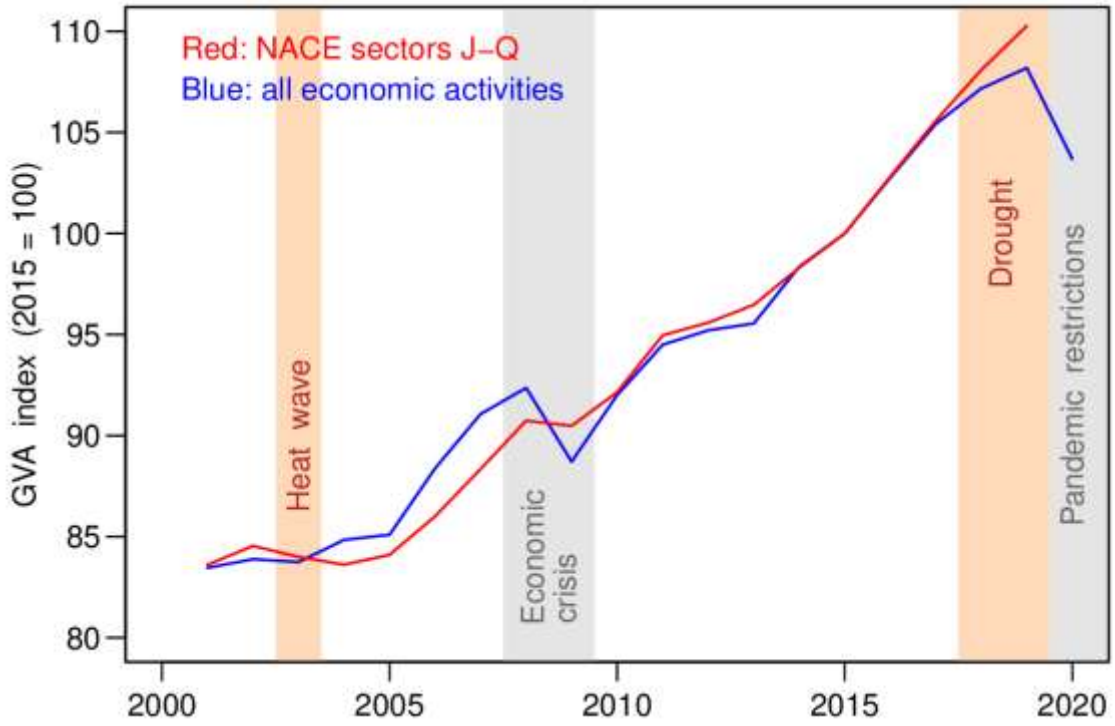


Figure 8. Two decades of economic activity in the five federal states representing the German Elbe River basin. Indexed gross value added (GVA) of the entire economy (blue) and the service sectors (red). Data Source: Statistische Ämter des Bundes und der Länder [statistical offices of the federation and the federal states].

Along the River Rhine and other rivers in Western Germany, navigation was however hampered by the low water levels so that oil refineries, steel mills and chemical industries (e.g. BASF) had to be shut down, diesel and gasoline supplies were locally broken, and the accumulated losses are probably in

the two-billion range. Several thermal power plants had to be throttled because of lacking cooling water, which points towards a potential tipping point under future droughts: As Germany's last nuclear plants and coal mines are currently being phased out from the energy mix, a drop in production from the remaining gas-driven thermal power plants could be critical for grid stability given the increasing shares of renewables (mainly wind and photovoltaics). A more detailed article about this research is currently in preparation for publication in a scientific journal.

Following a referee response to a manuscript about ABSOLUT (the statistical crop yield model used in CROSSDRO which was developed by Tobias Conradt (PIK) and originally submitted to Geoscientific Model Development in early 2021), the model code was cleaned from a systematic error, validation experiments re-computed, and a revision of the manuscript made and submitted for publication on 30 October. Fortunately, though the error principally caused considerable over-confidence in the model predictions, it hardly alters scenario calculations already made with the former version, e.g. for the Prut River basin.

The final months of 2021 were spent experimenting with the eco-hydrological model SWIM in the Havel River area to assess sensitivities of the plant–soil–groundwater systems and storages towards different drought levels. Furthermore, the set-up of a pan-European SWIM for continent-wide eco-hydrological modelling was commenced at PIK.

European-scale outputs

Vegetation responses to drought across European biomes

The Department of Physical Geography and Ecosystem Science of Lund University has investigated the association of vegetation productivity to meteorological drought across Europe using ERA5-Land derived SPEI and satellited-derived plant phenology index (PPI) for the period 2000 to 2020 on a bimonthly time step (Figure 1). The PPI is a vegetation index developed at Lund University. It keeps good properties of EVI (enhanced vegetation index) that have large dynamics for representing vegetation growth productivity and performs even better than EVI in seasonally snow-covered areas. PPI is thus advocated as an indicator for remote sensing vegetation productivity of European biomes by EEA (https://www.eea.europa.eu/data-and-maps/indicators/land-productivity-dynamics/assessment).

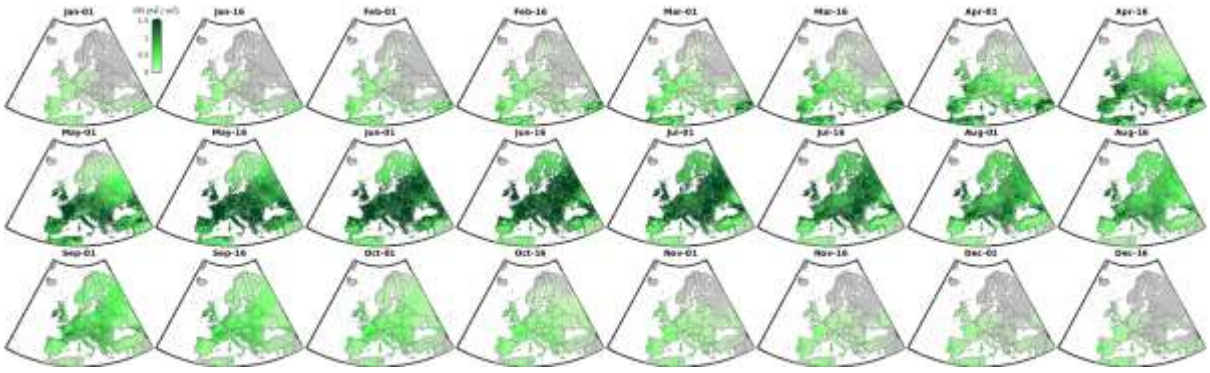


Figure 9. *Maximum bimonthly PPI from 2000 to 2020. The pixels with the maximum bimonthly PPI < 0.05 are regarded as having no active vegetation growth and were not considered in drought-vegetation association analysis.*

The bimonthly PPI data are used to analyse how the drought has affected vegetation growth for the period 2000 to 2020. It is found that European **droughts have prohibited vegetation productivity** over more than 50% of middle and southern European land areas (35°N to 55°N, Figure 10 and 11), prominently during peak growing season from June through September (large significant positive correlation between SPEI and PPI). In northern Europe the drought-affected land area was below 40% during the peak growing season. It is also found that **drought promoted vegetation productivity** (negative correlation in Figures 10, and 11), prominently at the start of the vegetation growing season — from April through June in northern Europe and from January through April in middle Europe.

It was suggested that vegetation growth promoted in drought period was probably due to the elevated air temperature along with increasing water deficit that promotes photosynthesis. A partial correlation analysis found that the proportions of negative correlative reduced, and positive correlation increased. In southern Europe, more than half of the proportion of drought-promoting-growth areas (negative correlation) turned out as drought-prohibiting-growth areas (positive correlation), evident in Figure 11 top panel vs the second panel. In northern and middle Europe, there were also negative-to-positive correlation changes by controlling temperature, but not as markedly as in southern Europe. When using incoming net radiation as a control, partial correlation analysis shows that more than half of the negative correlation turned into a positive correlation in middle Europe, and a large proportion changes in northern Europe. When using both temperature and net radiation as controlling factors to do partial correlation analyses between PPI and SPEI, we did not find added effects more than using air temperature or net radiation as a single control.

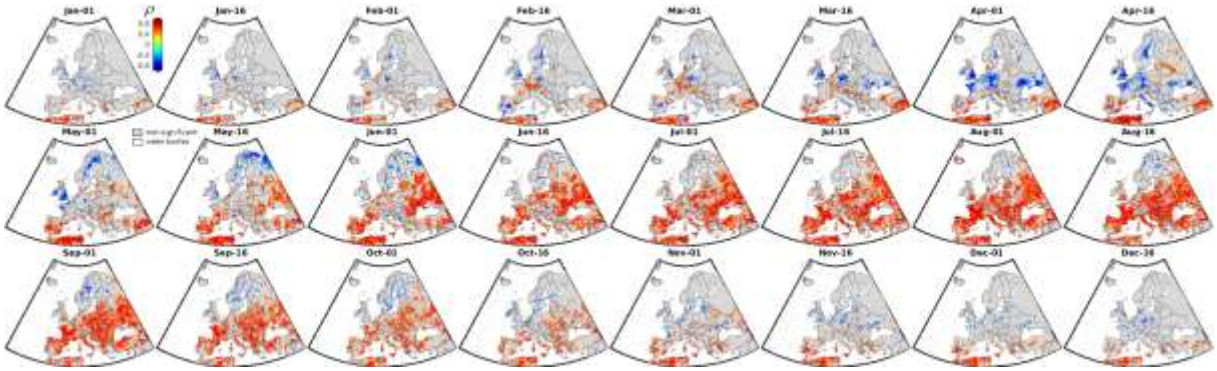


Figure 10. *Strongest partial correlation (significant at $p \leqslant 0.05$, positive or negative) of PPI to SPEI on bimonthly time step among all time scales from 1 to 24, by controlling incoming net radiation of the same time scale.*

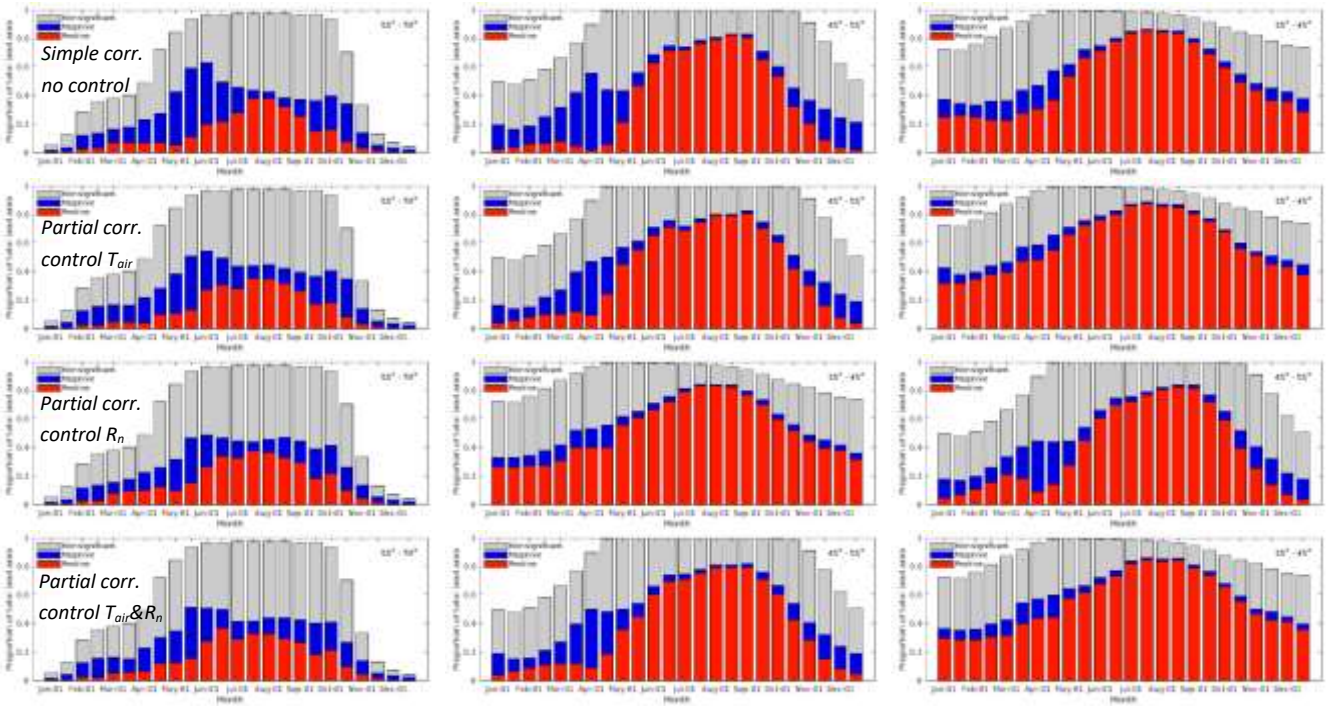


Figure 11. *The proportion of areas that has a strong correlation (significant at p⩽0.05, positive or negative) or no correlation (p>0.05) between PPI and SPEI on bimonthly step over three latitudinal zones of Europe biomes: north— 55 °N to 70 °N, middle— 45 °N to 55 °N, and south— 35 °N to 45 °N.*

This analysis shows that **meteorological drought hampered vegetation productivity during the peak growing season** but **promoted vegetation productivity at the start of the growing season**, when soil water availability (Figure 12) can still satisfy vegetation water demand (low water demand during the start of the season as evident by the low actual evapotranspiration). **The enhanced vegetation growth by meteorological drought is mainly due to either the elevated temperature** (in southern Europe) **or the increased radiation** (in middle Europe) along with reduced precipitation at the start of the growing season.

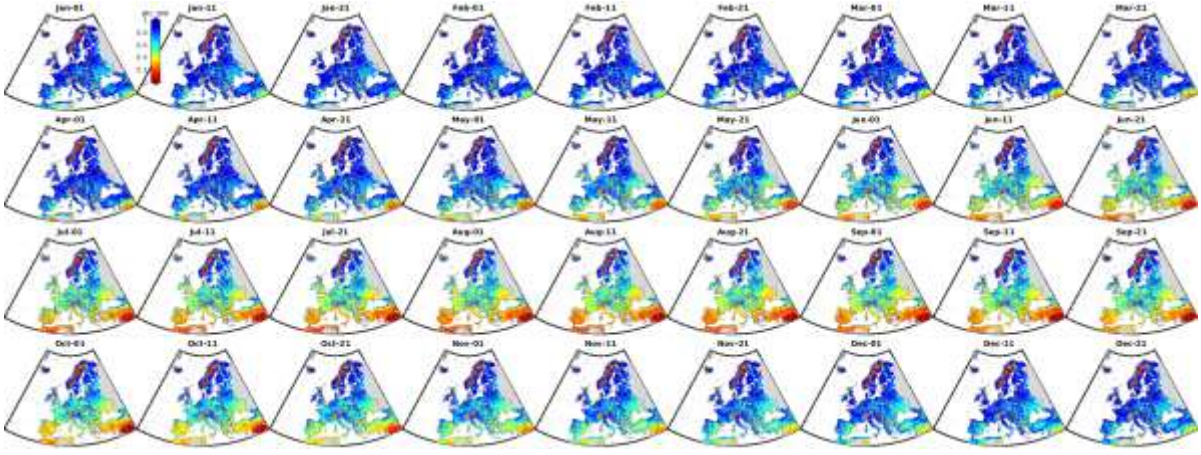


Figure 12. *Mean soil moisture index from 1995 to 2020 at dekad time step (from EDO Soil Moisture Index data)*

Our next step will be to summarize the PPI-SPEI association map and analyse how SPEI timescale (Figure 13) and time lag (Figure 14) were involved in drought -vegetation association.

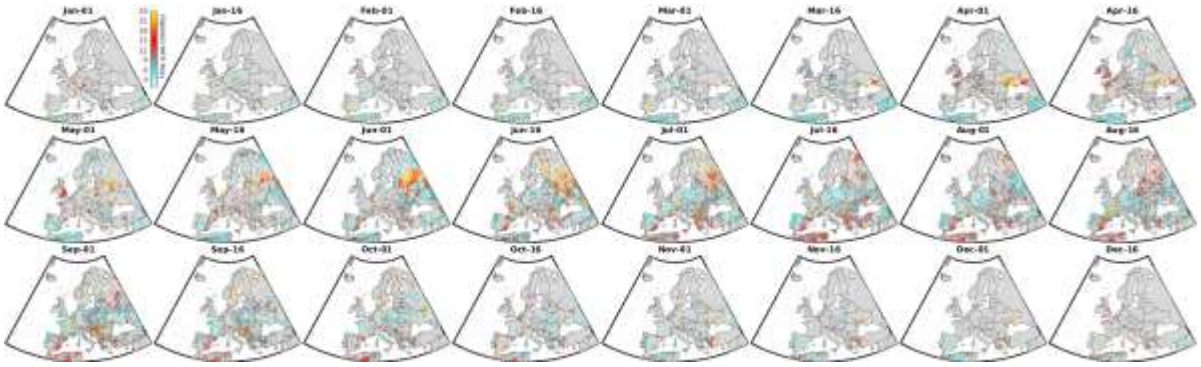


Figure 13. *The SPEI timescale with strongest partial correlation (significant at p⩽0.05, positive or negative) of PPI to SPEI on bimonthly time step, by controlling incoming net radiation of the same time scale.*

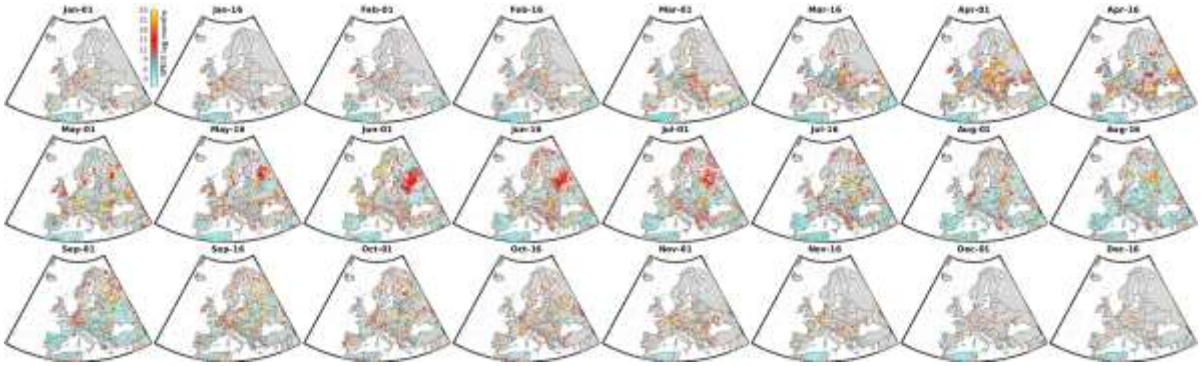


Figure 14. *The lag months of SPEI3 (3-month time scale of SPEI) that have the strongest partial correlation (significant at p⩽0.05, positive or negative) to PPI on bimonthly time step, by controlling incoming net radiation of the three months preceding PPI.*

Publications

Vicente-Serrano, S. M., Peña-Angulo, D., Murphy, C., López-Moreno, J. I., Tomas-Burguera, M., Domínguez-Castro, F., Tian, F., Eklundh, L., Cai, Z., Alvarez-Farizo, B., Noguera, I., Camarero, J. J., Sánchez-Salguero, R., Gazol, A., Grainger, S., Conradt, T., Boincean, B., & El Kenawy, A. (2021). The complex multi-sectoral impacts of drought: Evidence from a mountainous basin in the Central Spanish Pyrenees. Science of the Total Environment, 769, 144702.
https://doi.org/10.1016/j.scitotenv.2020.144702

Abstract: We analysed the impacts of drought severity on a variety of sectors in a topographically complex basin (the upper Aragón basin 2181 km2) in the Central Spanish Pyrenees. Using diverse data sources including meteorological and hydrological observations, remote sensing and tree rings, we analyse the possible hydrological implications of drought occurrence and severity on water availability in various sectors, including downstream impacts on irrigation water supply for crop production. Results suggest varying responses in forest activity, secondary growth, plant phenology, and crop yield to drought impacts. Specifically, meteorological droughts have distinct impacts downstream, mainly due to water partitioning between streamflow and irrigation channels that transport water to crop producing areas. This implies that drought severity can extend beyond the physical boundaries

of the basin, with impacts on crop productivity. This complex response to drought impacts makes it difficult to develop objective basin-scale operational definitions for monitoring drought severity. Moreover, given the high spatial variability in responses to drought across sectors, it is difficult to establish reliable drought thresholds from indices that are relevant across all socio-economic sectors. The anthropogenic impacts (e.g. water regulation projects, ecosystem services, land cover and land use changes) pose further challenges to assessing the response of different systems to drought severity. This study stresses the need to consider the seasonality of drought impacts and appropriate drought time scales to adequately assess and understand their complexity.

Grainger, S., Murphy, C., & Vicente-Serrano, S. M. (2021). Barriers and Opportunities for Actionable Knowledge Production in Drought Risk Management: Embracing the Frontiers of Co-production. Frontiers in Environmental Science, 9(April), 1–8. https://doi.org/10.3389/fenvs.2021.602128

Abstract: Drought risks pose serious threats to socio-ecological systems, built environments, livelihoods and human wellbeing. Managing these risks requires long-term collaboration between diverse groups with different values, interests and forms of knowledge. Funders, researchers and practitioners have increasingly advocated for collaborative models of knowledge production in which all participants recognise the multiple ways of understanding drought risk and strive to co-create knowledge for decision making. Such transdisciplinary research approaches aim to develop and sustain more equitable and meaningful interactions between scientific and societal actors, and have been shown to increase knowledge use and build resilience to climate variability. In practice, however, collaborations around drought remain largely science-driven and, as a result, can struggle to produce actionable knowledge necessary to better manage drought risk. This article draws from drought studies and related transdisciplinary fields to highlight common barriers inhibiting actionable knowledge production across a broad range of drought risk management contexts. We also propose opportunities for improved knowledge production that can guide researchers, practitioners and funders seeking to engage in transdisciplinary work. Diverse understandings of drought risk have hindered widespread advances in knowledge production and resilience building. We argue for multi-disciplinary researchers to come together with stakeholders and focus on creating inclusive and context-driven environments. While not appropriate or cost-effective in all situations, co-production between researchers, practitioners and other stakeholder groups offers opportunities for actionable management plans and policies that reflect the complex and contested problem framings and socio-ecological contexts in which droughts impact society.

Contact us

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CROSSDRO

ANNUAL NEWSLETTER

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National University of Ireland Maynooth

PIK

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NATIONAL AGENCY FOR RESEARCH AND DEVELOPMENT

FORMAS

No. 1 - December 2020

What is CROSSDRO?

CROSSDRO (*CROSS-sectoral impact assessment of DROughts in complex European basins*) is a EU JPI Climate project.

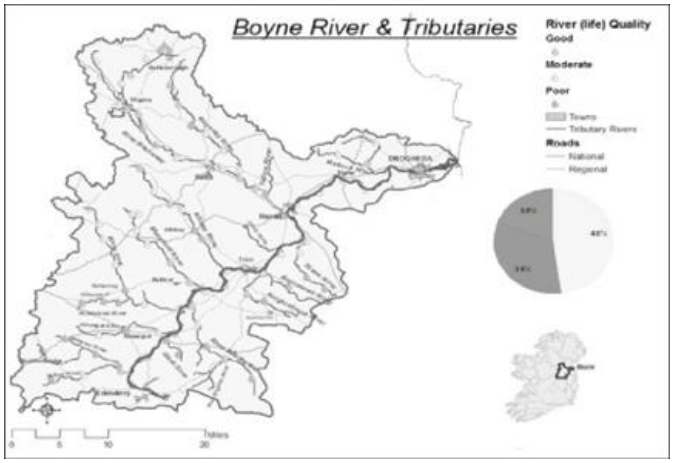
Where is the research taking place?

CROSSDRO is analysing drought in four European basins with very different socio-ecological contexts. Case study sites include:

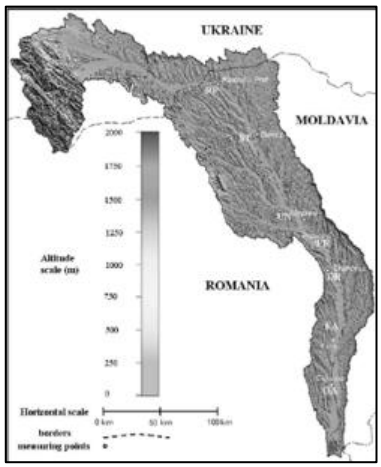
i) the upper Aragon basin in Northeast Spain,

ii) the German part of the Elbe basin,

iii) the Boyne basin in Ireland.



iv) the Moldovan part of Prut basin.



What are the project objectives?

The CROSSDRO objectives are to:

- Better understand the multi- and cross-sectoral impact of droughts including the connection between physical and socioeconomic impacts and pathways.
- Better understand stakeholder needs and perceptions of drought.
- Examine drought impact across scales – catchment to European scale, and both historically and into the future.

Who is involved?

CROSSDRO brings together scientists from five research institutions. The leading institution is the Spanish National Research Council, and the project coordinator is Sergio Vicente-Serrano. Partner institutions are University of Maynooth in Ireland (group leader C. Murphy), Lund University in Sweden (group leader L. Eklundh), Research Institute of Field Crops "Selectia" in Moldova (group leader B. Boincean) and Potsdam Institute for Climate Impact Research in Germany (group leader T. Conradt).

Progress so far…

As we are one year into the project, we would like to provide an update on the latest developments, project milestones and the big lessons we're learning in exploring cross-sectoral impacts of drought in Europe.

Kick off meeting in Balti, Moldova (January 2020)

The CROSSDRO kick off meeting was hosted by the project's Moldovan partner institution Research Institute of Field Crops "Selectia". The project team presented and discussed the proposed activities and outcomes of the project. PowerPoint files of the presentations are available on the project website: https://crossdro.csic.es/home/news/.

Stakeholder events

The CROSSDRO project aims to develop practical guidance for future planning through the strong engagement of drought-sensitive stakeholders in each basin. While the Covid-19 pandemic has disrupted stakeholder engagement to some extent, there has been considerable work completed including stakeholder mapping, initial stakeholder meetings and survey dissemination to get a sense of local stakeholder concerns.

Two stakeholder workshops in Aragón, Spain (December 2019 and February 2020)

These two workshops were attended by representatives from the agricultural, livestock and forestry sector, the local and regional administration, the field of research, environmental associations and civil society. We introduced the project and noted the wide range of stakeholder perspectives and concerns around the impact of drought on water resources, agriculture, fisheries, forests, ecology and indirectly on tourism and the economy in the region. The project team suggested that tailored early warning systems based on in-depth studies in the region may help them anticipate and prepare for drought events. Participants also highlighted the role of insurance and importance of effective communication when trying to engage with local politicians and the general public.

Welcome to the club - Ludwigsfelde under palm trees in the Brandenburg sand? (13 January 2020)

As part of an ongoing collaboration with the Ludwigsfelde council, Potsdam meteorologist Peter Hoffmann attended a public meeting at the town hall about rising temperatures and their risks in the state of Brandenburg: https://www.ludwigsfelde.de/veranstaltung/willkommen-im-klub-ludwigsfelde-unter-palmen-im-maerkischen-streusand-2/

National drought planning meeting in Ireland (June 2020)

Prof Conor Murphy met with national stakeholders regarding the objectives and early output from the project. These included the Irish Environmental Protection Agency, state-run water utility, Meteorological Agency, Geological Agency, Water Forum and the Federation for community-managed water supply. Arising from the exceptionally dry spring experienced in Ireland this year and concerns about drought, this high-level group was convened to discuss the communication of drought impacts and warnings. Insight from the project was provided in terms of cross sectoral drought impacts and insights derived from initial engagement with stakeholders. The group will continue to meet in the future to discuss a national strategy for managing hydrological droughts.

Business dialogues in Germany

The project team at the Potsdam Institute for Climate Impact Research took the opportunity to connect CROSSDRO with their business dialogue activities utilizing several meetings and ongoing cooperation with – i.e., Stadtwerke Potsdam (the Potsdam water works), Nordzucker (Germany's second largest sugar producer), Deutsche Bahn (the German national railways), or Vattenfall (Sweden's state-owned electricity provider which operates some of Berlin's thermal power plants).

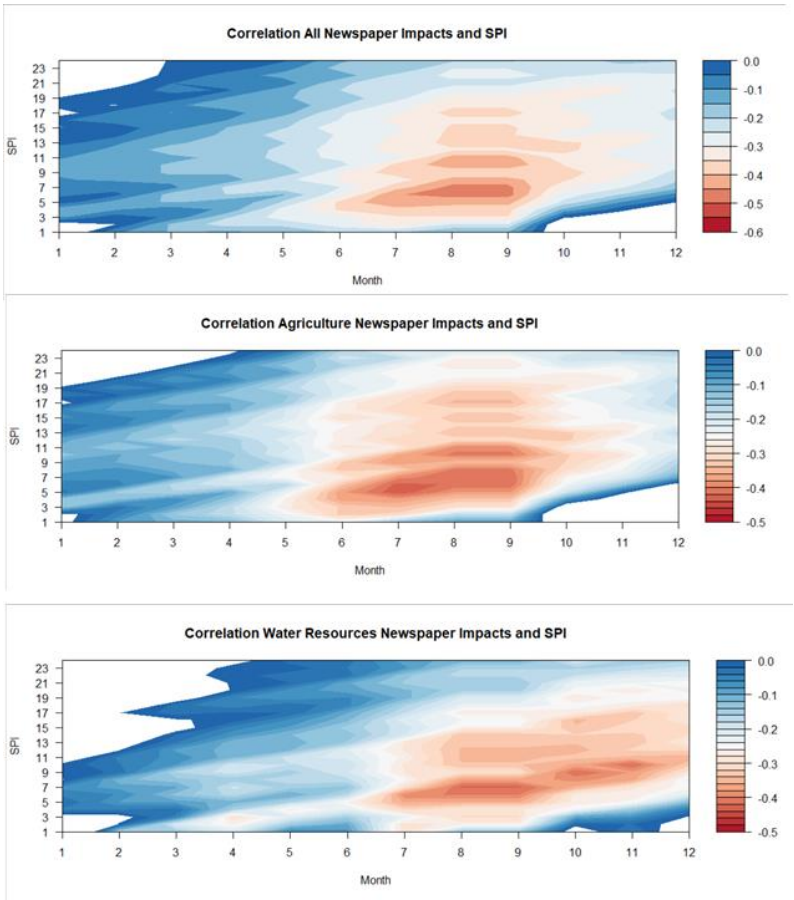
Meeting with Prime Minister of Moldova (July 2020)

The Prime Minister of Moldova visited partner institution, Selectia Research Institute of Field Crops in Balti city. They discussed lessons to be learned by farmers from the very severe drought in 2020 and potential measures that can be undertaken in order to revitalize the seed production for field crops, mainly for local varieties which have proven highly resilient to drought. Meeting participants agreed that challenges faced by modern agriculture, including global warming, can be overcome through the implementation of a new strategy for agriculture intensification based on the principles of agroecology.

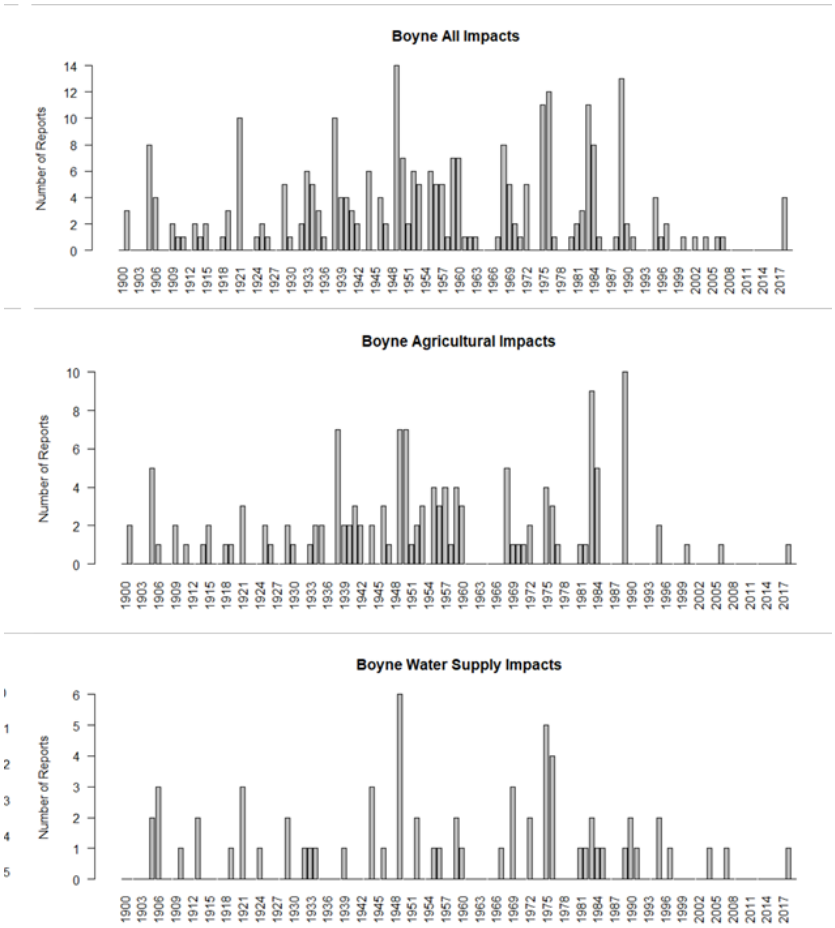
Boyne Basin, Ireland

Reconstructing and understanding droughts and their impacts in the Boyne catchment

The Boyne catchment in Eastern Ireland has been subject to extensive arterial drainage. Little is known of the impact of such activities on drought dynamics. We have rescued paper records of observations, held in meteorological archives, to extend catchment precipitation records back to 1850. Using this long-term quality assured series, we have been able to reconstruct river flows for the Boyne catchment to investigate how arterial drainage impacts hydrological drought and the propagation of meteorological to hydrological events. In summary, we find that drainage makes droughts shorter lived and less intense. We have also completed work linking drought metrics to impacts in the catchment to understand the cross sectoral impacts of drought. This has been achieved using newspaper records and remote sensing data. Newspaper records give us an insight into the changing nature of vulnerability to drought over time and allow us to identify the most appropriate metrics for monitoring drought impacts. For more recent periods, remote sensing information allows drought vulnerability of key land use types (including peat bogs, forestry, crop land and pasture) to be examined. Our paper is currently in preparation.



Correlation between monthly Standardised Precipitation Index (SPI) of various accumulation periods with all newspaper reported impacts (top), agricultural impacts (middle) and hydrological impacts (bottom) in the Boyne catchment over the period 1900-2019.



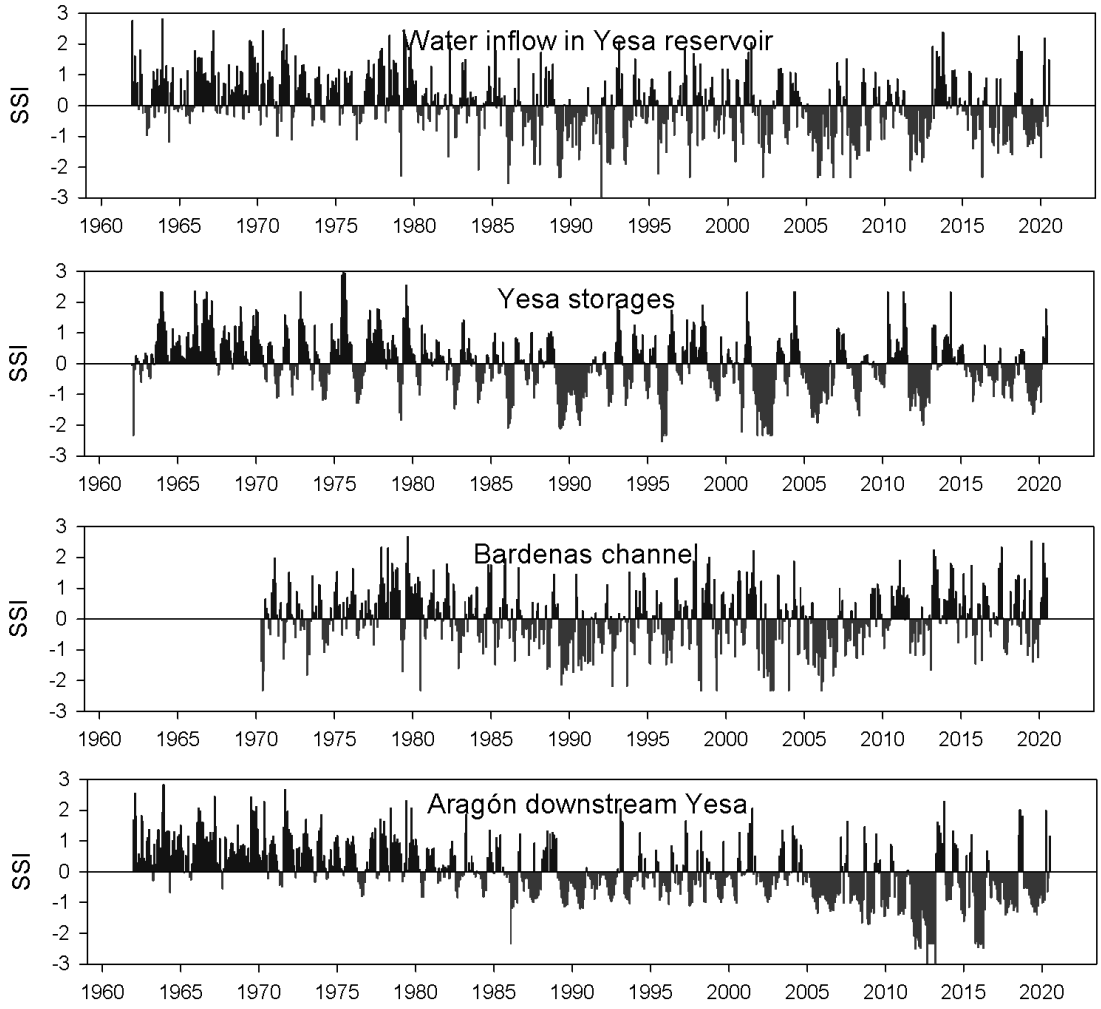
Number of drought reports in local newspapers in the Boyne catchment per year for the period 1900-2019.

Aragon Basin, Spain

Multisectoral analysis of drought impacts in the upper Aragón basin

We have analysed the impacts of drought severity on a variety of sectors in the upper Aragón basin. Using diverse data sources including meteorological and hydrological observations, remote sensing and tree rings, we have analysed the possible hydrological implications of drought occurrence and severity on water availability in various sectors, including downstream impacts on irrigation water supply for crop production. Results suggest varying responses in forest activity, secondary growth, plant phenology, and crop yield to drought impacts. Specifically, meteorological droughts have distinct impacts downstream, mainly due to water partitioning between streamflow and irrigation channels that transport water to crop producing areas. This implies that drought severity can extend beyond the physical boundaries of the basin, with impacts on crop productivity. This complex response to drought impacts makes it difficult to develop objective basin-scale operational definitions for monitoring drought severity. Moreover, given the high spatial variability in responses to drought across sectors, it is difficult to establish reliable drought thresholds from indices that are relevant across all socio-economic sectors. The anthropogenic impacts (e.g., water regulation projects,

ecosystem services, land cover and land use changes) pose further challenges to assessing the response of different systems to drought severity.



Evolution of hydrological drought, as revealed by the Standardised Streamflow Index (SSI), computed for the period 1962-2020. SSI was calculated using water inflows, reservoir storages, Bardenas channel flow and the Aragón River downstream the Yesa reservoir.

Prut Basin, Moldova

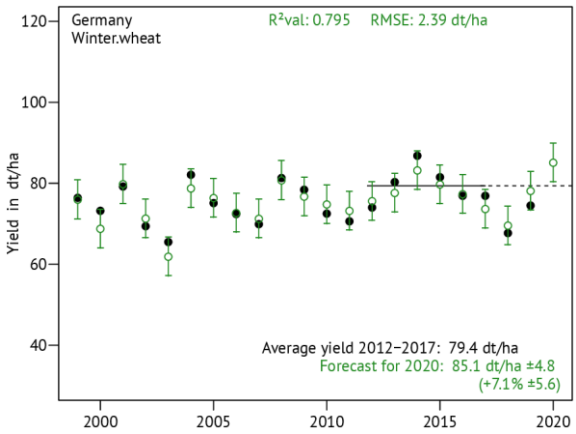
In 2020 the Republic of Moldova faced one of the most severe droughts in its history. Annual precipitation was 168 mm lower than the historical average and annual temperature was 2.7 °C higher than the historical average. Crop yields have been significantly higher in crop rotations than in continuous cropping both on fertilized and unfertilized plots. For example, winter wheat yields in crop rotation, after planting vetch and oats, were between 3,48 and 4,02 t/ha, respectively. On the contrary, winter wheat yields in continuous cropping were between 1.49 and 1.80 t/ha. This means that yield reduction in continuous winter wheat relatively to crop rotation was between 1,99 and 2,22 t/ha.

We found that crop rotation, soil fertility and more efficient soil moisture use significantly reduces the negative influence of drought. Experimental data have been obtained for a large spectrum of crops grown in crop rotation and in continuous cropping in the condition of extreme drought in 2020. Simultaneously experimental data have been obtained for different crops under different systems of soil tillage and fertilization in crop rotations. The results obtained in the long-term field experiments have been published in the book: "Farming the Black Earth: Sustainable and resilient management of chernozem soil" (Boincean and Dent, 2019). The book was translated and published also in Russian and Romanian languages during 2020. The results of the long-term field experiments are of crucial importance for proving the necessity of respecting a whole farming system capable to restore soil fertility as the main precondition for transition to a more sustainable farming system.

Elbe Basin, Germany

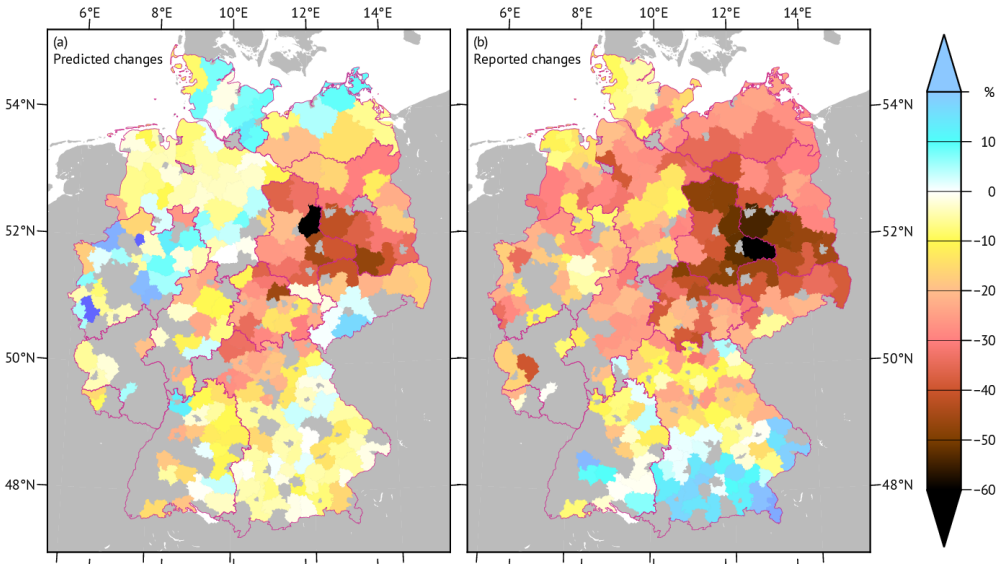
Drought lasts longer than sunny weather – an experience from crop yield model development in Germany

The severe Central European drought of 2018 might have been a trigger for setting the research focus of CROSSDRO, but nobody would have anticipated the following years 2019 and 2020 practically demonstrating the persistence effects of drought in agricultural soils. This could be observed in Germany in the course of testing a new approach in statistical crop modelling: In its current stage (ABSOLUT v.1.0, manuscript in preparation) the model utilizes monthly weather aggregates as regression input but neglects hysteretic system elements like soil water storage. Consequently, pre-harvest national yield predictions for the years 2019 and 2020 (not as dry as 2018, but still affected by below average precipitation) became too optimistic.



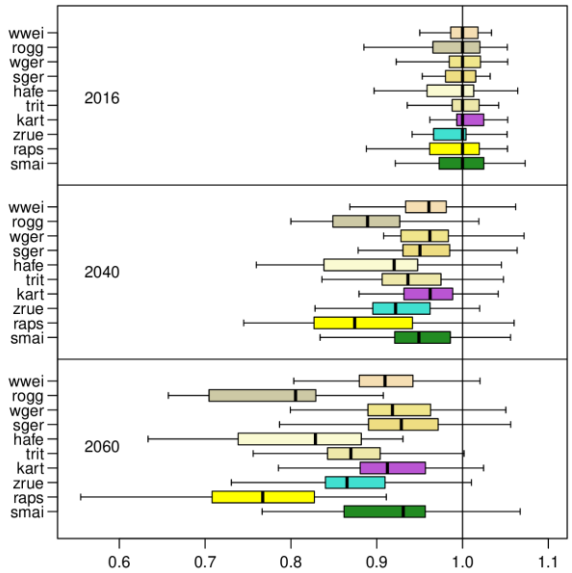
Out-of-sample pre-harvest predictions of Germany's national average yields of winter wheat, solely based on monthly averages of air temperature, precipitation, and sunshine duration. Predictions and their confidence intervals are drawn in green; the black dots are the observed values. The most recent estimation of the Federal Statistical Office (issued on 24 September) for 2020 is at 78.9 dt/ha, 7.2 dt/ha short of the forecast.

Nevertheless, the model is able to roughly reproduce spatial hotspots of drought-induced yield losses as the comparison of county-level predictions and observations illustrates for the case of silage maize in 2019:



Predicted and reported 2019 silage maize yields: relative changes to 2012–2017 (before drought) yield averages

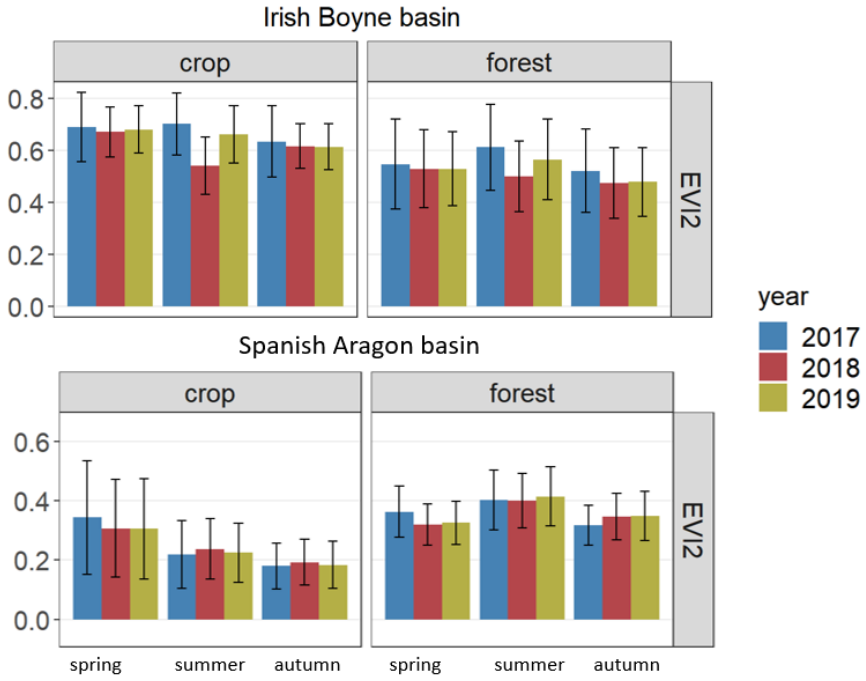
Driving the crop yield model with climate scenarios allows for estimating climate change effects on yield levels. Finally, we present a first example of such a scenario calculation for the central part of the German Elbe basin, the area with the most severe yield losses under drought conditions (−40% and less in the right-hand map above). According to these preliminary results, rye, oats, and rape are losing more relative yield potential than other crops under climate change. Interestingly, the same crops are still grown more frequently in this region than in other parts of Germany.



Agricultural yield scenario of the ABSOLUT v.1.0 model for the Central German Elbe basin based on a CMIP5 RCP 8.5 climate scenario consisting of 21 EURO-CORDEX model chains bias-adjusted at PIK. The boxplots show the distributions of yield potentials for ten different crops induced by the diversity of climate scenario realisations. Yield potentials are given relative to the median yields around the reference year 2016 (=1.0). Crops are abbreviated as follows: wwei = Winter wheat, rogg = Rye, wger = Winter barley, sger = Spring barley, hafe = Oats, trit = Triticale, kart = Potatoes, zrue = Sugar beets, raps = Winter rape, smai = Silage maize.

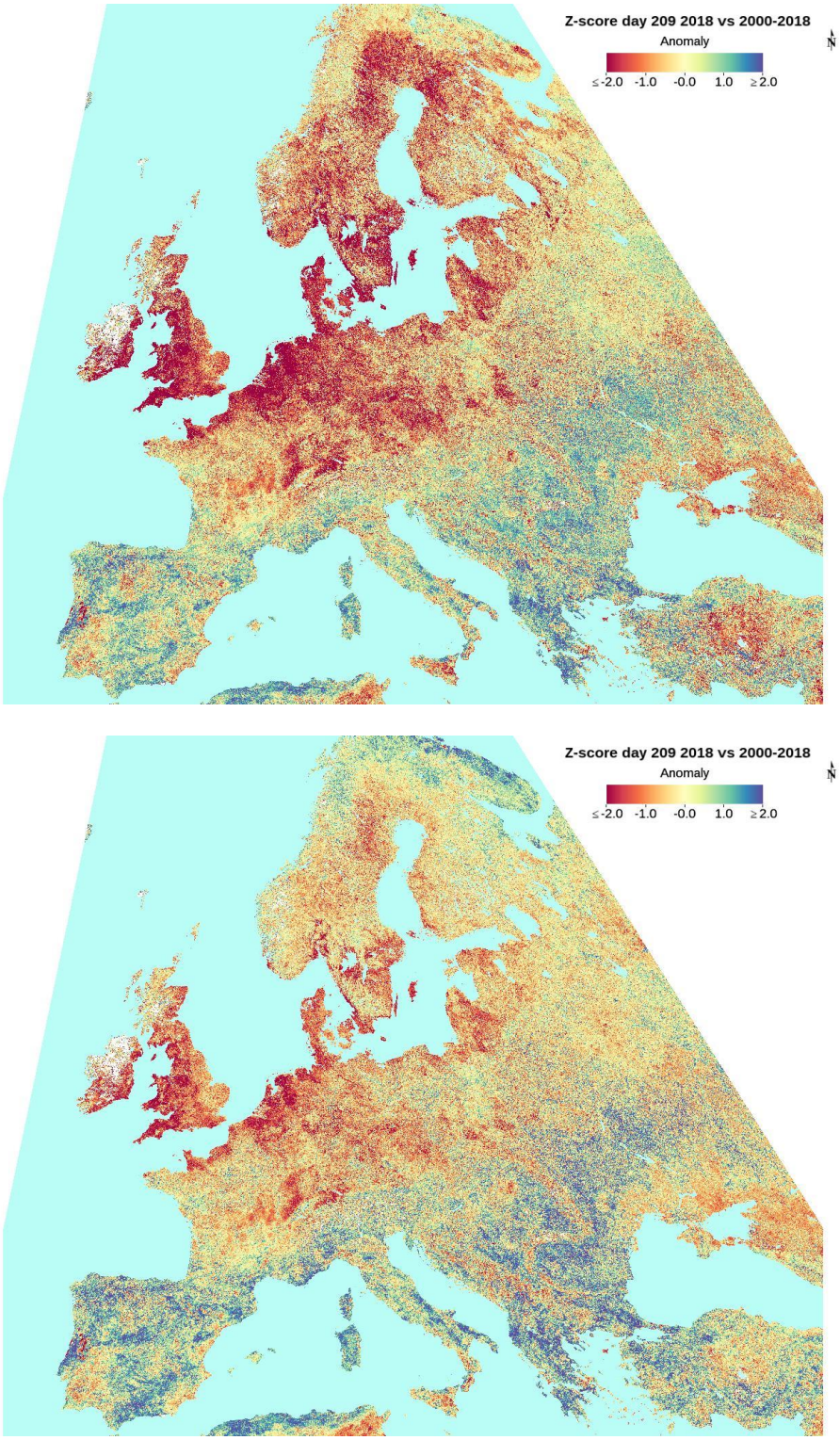
Satellite studies of drought impacts on vegetation

We have generated data for studying drought impact on agriculture and forestry at basin scale and at the European scale. For individual basins we have used Copernicus/Sentinel-2 data for the period 2017-2019 in order to study the impacts on vegetation due to the 2018 drought. An example is given in the figure below, showing vegetation productivity, estimated by the index EVI2, to indicate drought effects for the different years in the Irish Boyne basin and the Spanish Aragon basin, for crops and agriculture. The figure shows that the impact of the 2018 drought was more pronounced in Boyne, Ireland, than in Aragon, Spain. Both crops and forest in the Irish basin showed considerably lower vegetation productivity during the summer of 2018 compared to the other summers. Impacts during spring and autumn were also seen but not as strongly.



Variations in EVI2 for the Boyne and Aragon basins, years 2017-19.

At the European scale we have compared satellite-derived vegetation indices from the NASA/MODIS sensor that indicate different aspects of drought. The European maps in the figure below shows the difference in response to the 2018 drought between the Normalized Difference Water Index (NDWI) and the Plant Phenology Index (PPI). NDWI is an index that responds to the moisture level in tree canopies and upper soil layer. It is seen that there were widespread areas of negative anomaly throughout large parts of N. Europe, spreading as far south as the border to the Alps (top map). On the other hand, the PPI, which is an index responding to effects on the green vegetation canopy, shows that reduction in green canopy biomass occurred in a much more limited area of Europe (bottom map). Most of the negative anomalies occurred in the cropland areas of Europe, and forest areas were affected to a lower degree. We interpret the difference in response as an effect of different resilience to the water deficiency in different geographical areas and vegetation types. Further analyses will be made to quantify the effect and attribute it to vegetation properties.



Anomalies in the indices NDWI (top) and PPI (bottom) for the year 2018 compared to the 2000-2018 mean situation (z-scores). Negative anomalies are shown as red colours and positive as green-blue colours.

Grainger, S., Murphy, C., Vicente Serrano, S.M. Barriers and opportunities for actionable knowledge production in drought risk management: embracing the frontiers of co-production. Frontiers in Environmental Science (In review).

Abstract: Drought risks pose serious threats to livelihoods and human wellbeing. Managing these risks requires collaboration between diverse groups with different values, interests and forms of knowledge. Funders, researchers and practitioners have increasingly advocated for collaborative models of knowledge production and management in which all participants recognise the multiple ways of understanding drought risk and strive to co-create knowledge for decision making. This transdisciplinary research approach, involving equitable and meaningful interactions between scientific and societal actors, has been shown to increase knowledge use. In practice, however, collaborations around drought remain largely science-driven and, as a result, can struggle to produce actionable knowledge necessary to better manage drought risk. This article draws from drought studies and related transdisciplinary fields that share similar epistemic foundations and risk-based decision-making contexts to highlight critical barriers inhibiting actionable knowledge production for drought risk management. We also propose opportunities for improved knowledge production that can guide researchers, practitioners and funders seeking to engage in transdisciplinary research. We argue for the social sciences and humanities to have a more prominent role in planning and facilitating stakeholder interactions, creating an enabling environment that accommodates a diverse understanding of drought, and opening up the cultural, political and institutional dimensions of knowledge-making practices. From this, researchers, practitioners and other stakeholder groups will be better able to develop actionable management plans and policies that reflect the complex and contested socio-ecological contexts in which droughts impact society.

Noguera, I., Domínguez-Castro, F., Vicente-Serrano, S.M. (2020) Characteristics and trends of flash droughts in Spain (1961-2018). Annals of the New York Academy of Sciences. 1472, 155-172

Abstract: Flash droughts are characterized by rapid onset and intensification, as well as major environmental and agricultural impacts. In this study, we developed an objective method for identifying flash droughts using the standardized evaporation precipitation index (SPEI) based on a short time scale (1-month) and high-frequency data (weekly). The identification of flash droughts was focused on the development phase, anomalous decreases in index values in a short time period (4 weeks), and the magnitude of the events. The method was applied to mainland Spain and the Balearic Islands using a high spatial resolution gridded dataset for the period 1961–2018. For this period of 58 years, we characterized the occurrence of flash droughts and showed that for Spain, there was a large spatial and temporal variability in their frequency, with more occurring in the northwest than in the central and southern regions. The northern regions, where a higher frequency of flash droughts was found, showed negative trends in the frequency of flash droughts, while the regions subject to fewer flash drought events showed generally positive trends. We investigated the relative frequency of flash droughts affecting the study regions and found that they are a common phenomenon, as 40% of all

droughts were characterized by rapid development. The findings of this study have important implications for drought assessment, monitoring, and mitigation.

O'Connor, P., Murphy, C., Matthews, T., & Wilby, R. L. (2020). Reconstructed monthly river flows for Irish catchments 1766–2016. Geoscience Data Journal, August, gdj3.107. https://doi.org/10.1002/gdj3.107

A 250-year (1766–2016) archive of reconstructed river flows is presented for 51 catchments across Ireland. By leveraging meteorological data rescue efforts with gridded precipitation and temperature reconstructions, we develop monthly river flow reconstructions using the GR2M hydrological model and an Artificial Neural Network. Uncertainties in reconstructed flows associated with hydrological model structure and parameters are quantified. Reconstructions are evaluated by comparison with those derived from quality assured long-term precipitation series for the period 1850–2000. Assessment of the reconstruction performance across all 51 catchments using metrics of MAE (9.3mm/month; 13.3%), RMSE (12.6mm/month; 18.0%) and mean bias (−1.16mm/month; −1.7%), indicates good skill. Notable years with highest/lowest annual mean flows across all catchments were 1877/1855. Winter 2015/16 had the highest seasonal mean flows and summer 1826 the lowest, whereas autumn 1933 had notable low flows across most catchments. The reconstructed database will enable assessment of catchment specific responses to varying climatic conditions and extremes on annual, seasonal and monthly timescales

Tomas-Burguera, M., Vicente-Serrano, S.M., Peña-Angulo, D., Domínguez-Castro, F., Noguera, I., El Kenawy, A. (2020) Global characterization of the varying responses of the Standardized Evapotranspiration Index (SPEI) to atmospheric evaporative demand (AED). Journal of Geophysical Research-Atmosphere. 125, e2020JD0330178

Abstract: The Standardized Precipitation Evapotranspiration Index (SPEI) is one of the well-established drought metrics worldwide. It is simply computed using precipitation and atmospheric evaporative demand (AED) data. Although AED is considered a key driver of drought variability worldwide, it could have less impact on drought in specific regions and for particular times as a function of the magnitude of precipitation. Specifically, the influence of the AED might overestimate drought severity during both normal and humid periods, resulting in "false alarms" about drought impacts on physical and human environments. Here, we provided a global characterization of the sensitivity of the SPEI to changes of the AED. Results demonstrate that the contribution of AED to drought severity is largely impacted by the spatial and temporal variability of precipitation. Specifically, the impact of AED on drought severity was more pronounced during periods of low precipitation, compared to wet periods. Interestingly, drought severity in humid regions (as revealed by SPEI) also showed low sensitivity to AED under drier conditions. These results highlight the skill of SPEI in identifying the role of AED in drought evolution, especially in arid and semi-arid regions whose climate is characterized typically by low precipitation. This advantage was also evident for humid environments, where SPEI did not

overestimate drought severity due to the increased AED. These findings highlight the broader applicability of SPEI to accurately characterize drought severity worldwide.

Vicente-Serrano, S. M., Peña-Gallardo, M., Hannaford, J., Murphy, C., Lorenzo-Lacruz, J., Dominguez-Castro, F., López-Moreno, J. I., Beguería, S., Noguera, I., Harrigan, S., & Vidal, J. -P. (2019). Climate, irrigation, and land-cover change explain streamflow trends in countries bordering the Northeast Atlantic. Geophysical Research Letters, 821–833. https://doi.org/10.1029/2019gl084084

Plain Language Summary: Reduced water resources availability is one of the most serious impacts of climate change since reductions in streamflow may cause noticeable ecological and socioeconomic impacts. However, attribution of streamflow trends to climate change is complex given the influence of other drivers of catchment change, including human and vegetation water uses, agriculture, and land use change. We show that for north-western Europe most observed trends in annual streamflow are associated with climate change. However, in southwestern Europe there is a clear mismatch between observed trends in river flows and climate, with increasing vegetation and/or irrigated agriculture better explaining observed changes. Our results highlight the importance of human management in explaining large-scale hydrological trends and the need to carefully evaluate both climate and land use changes to disentangle drivers of streamflow trends.

Vicente-Serrano, S. M., Domínguez-Castro, F., Murphy, C., Hannaford, J., Reig, F., Peña-Angulo, D., Tramblay, Y., Trigo, R. M., Mac Donald, N., Luna, M. Y., Mc Carthy, M., Van der Schrier, G., Turco, M., Camuffo, D., Noguera, I., García-Herrera, R., Becherini, F., Della Valle, A., Tomas-Burguera, M., & El Kenawy, A. (2020). Long-term variability and trends in meteorological droughts in Western Europe (1851–2018). International Journal of Climatology, joc.6719. https://doi.org/10.1002/joc.6719

Abstract: We analysed long-term variability and trends in meteorological droughts across Western Europe using the Standardized Precipitation Index (SPI). Precipitation data from 199 stations spanning the period 1851–2018 were employed, following homogenisation, to derive SPI-3 and SPI-12 series for each station, together with indices on drought duration and severity. Results reveal a general absence of statistically significant long-term trends in the study domain, with the exception of significant trends at some stations, generally covering short periods. The largest decreasing trends in SPI-3 (i.e., increasing drought conditions) were found for summer in the British and Irish Isles. In general, drought episodes experienced in the last two or three decades have precedents during the last 170·years, emphasizing the importance of long records for assessing change. The main characteristic of drought variability in Western Europe is its strong spatial diversity, with regions exhibiting a homogeneous temporal evolution. Notably, the temporal variability of drought in Western Europe is more dominant than long-term trends. This suggests that long-term drought trends cannot be confirmed in Western Europe using precipitation records alone. This study provides a long-term regional assessment of drought variability in Western Europe, which can contribute to better understanding of regional climate change during the past two centuries.

Vicente-Serrano, S.M. Fernando Domínguez-Castro, Tim R. McVicar, Miquel Tomas-Burguera, Marina Peña-Gallardo, Iván Noguera, Juan I. López-Moreno, Dhais Peña, Ahmed El Kenawy. (2020) Global characterization of hydrological and meteorological droughts under future climate change: The importance of timescales, vegetation-CO2 feedbacks and changes to distribution functions. Int. J. Climatol. 40: 2547-2557.

Abstract: There is a strong scientific debate on how drought will evolve under future climate change. Climate model outputs project an increase in drought frequency and severity by the end of the 21st century. However, there is a large uncertainty related to the extent of the global land area that will be impacted by enhanced climatological and hydrological droughts. Although climate metrics suggest a likely strong increase in future drought severity, hydrologic metrics do not show a similar signal. In the literature, numerous attempts have been made to explain these differences using several physical mechanisms. This study provides evidence that characterization of drought from different statistical perspectives can lead to unreliable detection of climatological/hydrological droughts in model projections and accordingly give a "false alarm" of the impacts of future climate change. In particular, this study analyses future projections based on different drought metrics and stresses that detecting trends in drought behaviour in future projections must consider the extreme character of drought events by comparing the percentage change in drought magnitude relative to a reference climatological period and rely on the frequency of events in the tail of the distribution. In addition, the autoregressive character of drought indices makes necessary the use of the same temporal scale when comparing different drought metrics in order to maintain comparability. Taking into consideration all these factors, our study demonstrates that climatological and hydrological drought trends are likely to undergo similar temporal evolution during the 21st century, with almost 30% of the global land areas experiencing water deficit under future greenhouse gas emissions scenarios. As such, a proper characterization of drought using comparable metrics can introduce lower differences and more consistent outputs for future climatic and hydrologic droughts.

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