CROSSDRO

ANNUAL NEWSLETTER

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No. 1 - December 2020

What is CROSSDRO?

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

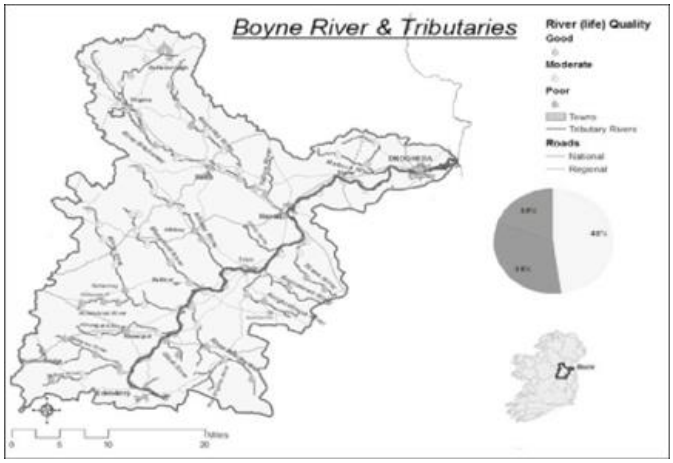
Where is the research taking place?

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

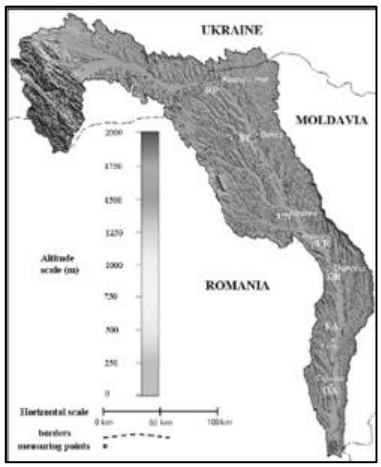
i) the upper Aragon basin in Northeast Spain,

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).

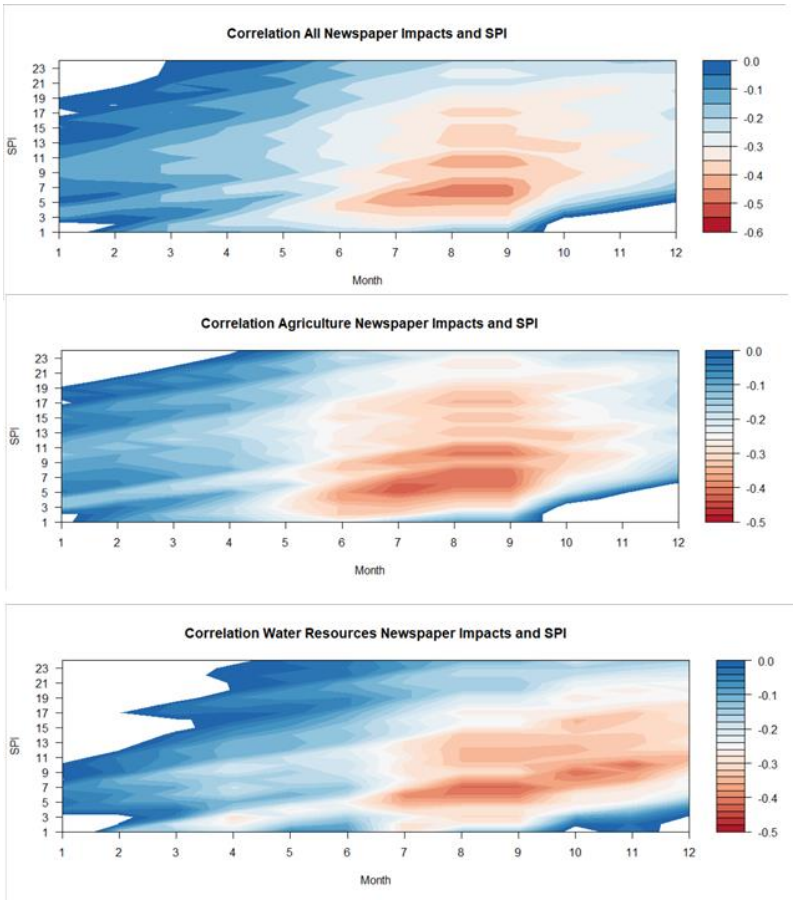
Meeting with Prime Minister of Moldova (July 2020)

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.

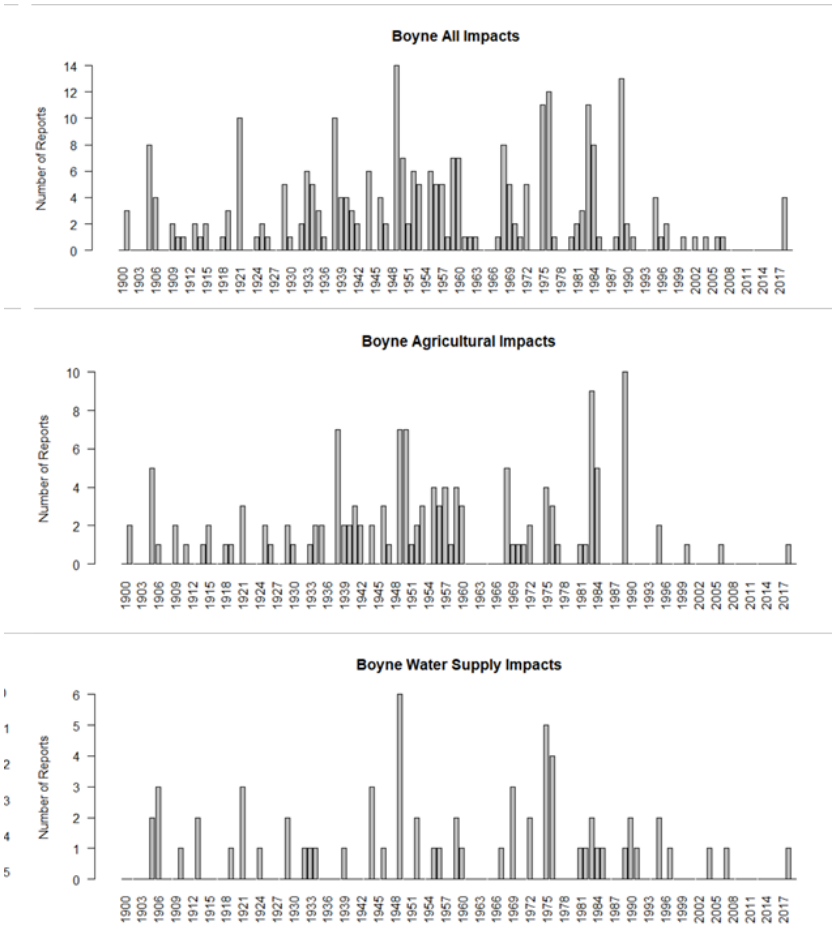
Boyne Basin, Ireland

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.



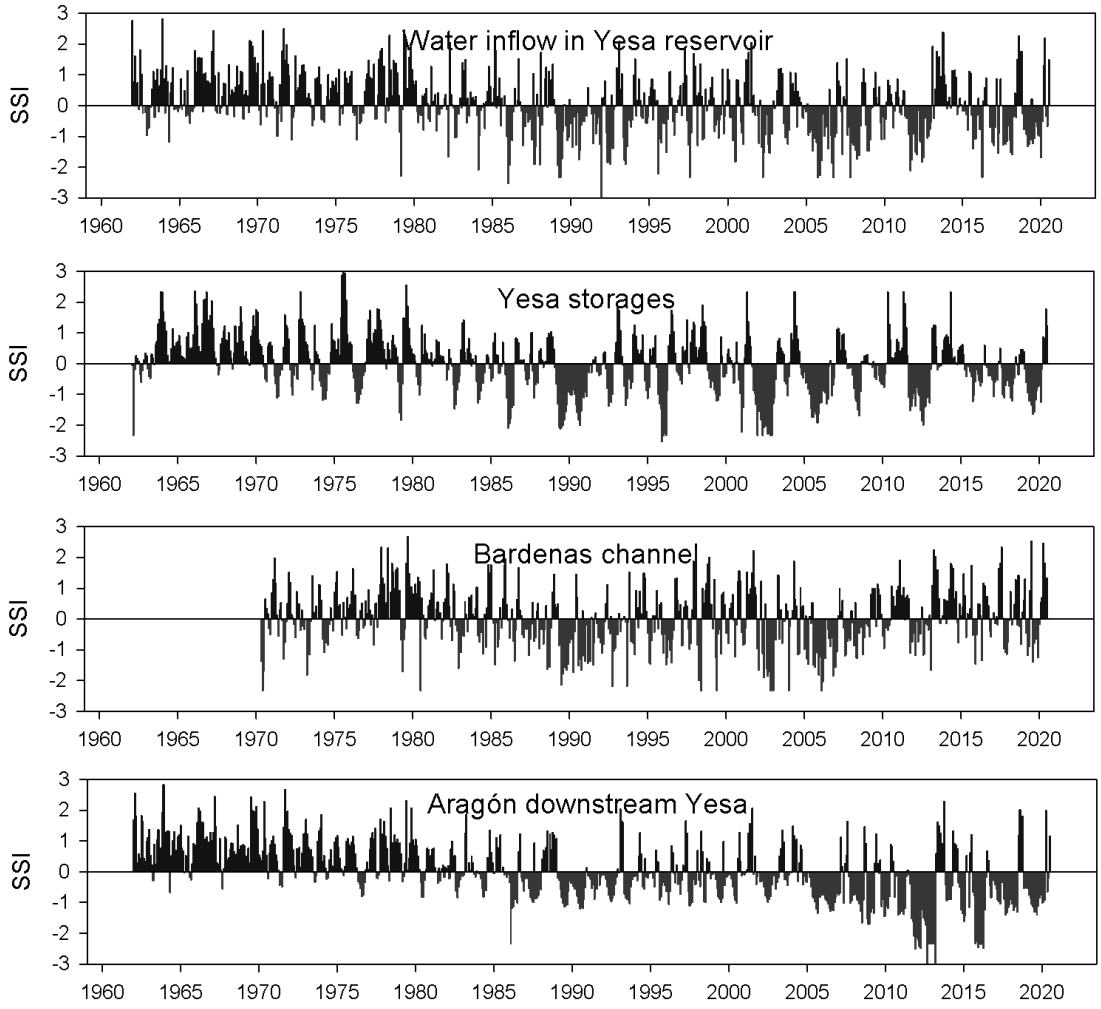
Number of drought reports in local newspapers in the Boyne catchment per year for the period 1900-2019.

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

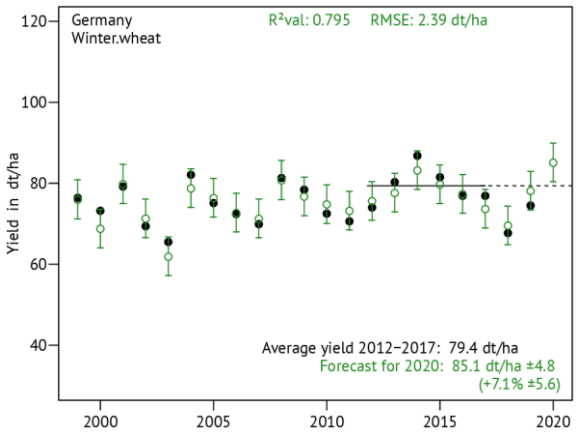
In 2020 the Republic of Moldova faced one of the most severe droughts in its history. Annual precipitation was 168 mm lower than the historical average and annual temperature was 2.7 °C higher than the historical average. Crop yields have been significantly higher in crop rotations than in continuous 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

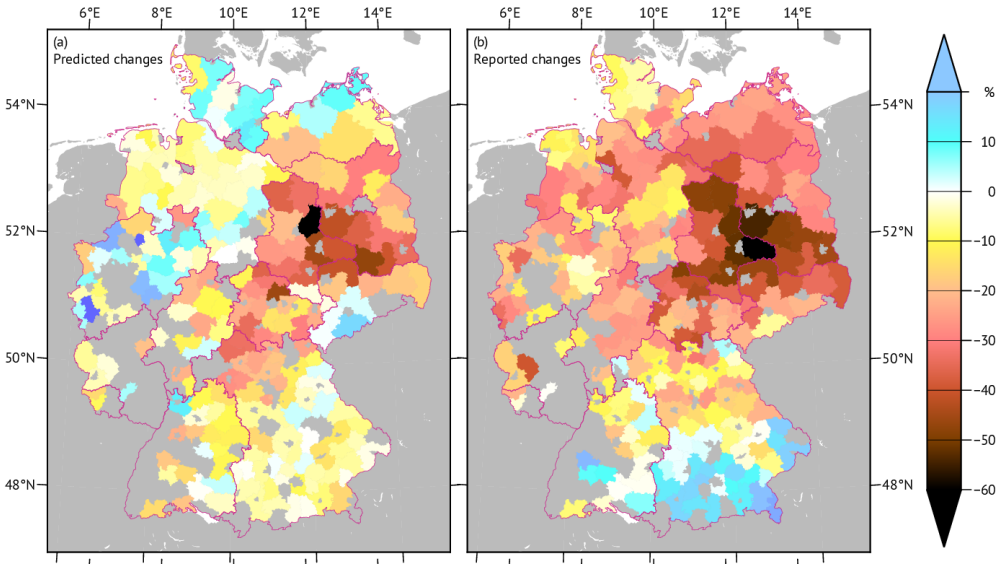
Drought lasts longer than sunny weather – an experience from crop yield model development in Germany

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.



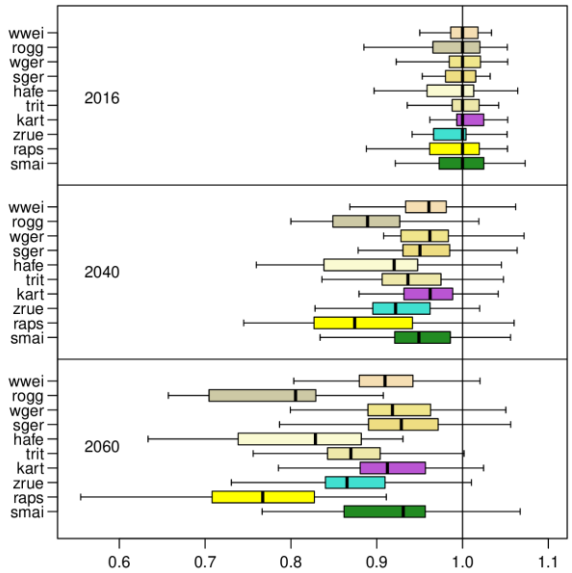
Out-of-sample pre-harvest predictions of Germany's national average yields of winter wheat, solely based on monthly averages of air temperature, precipitation, and sunshine duration. Predictions and their confidence intervals are drawn in green; the black dots are the observed values. The most recent 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

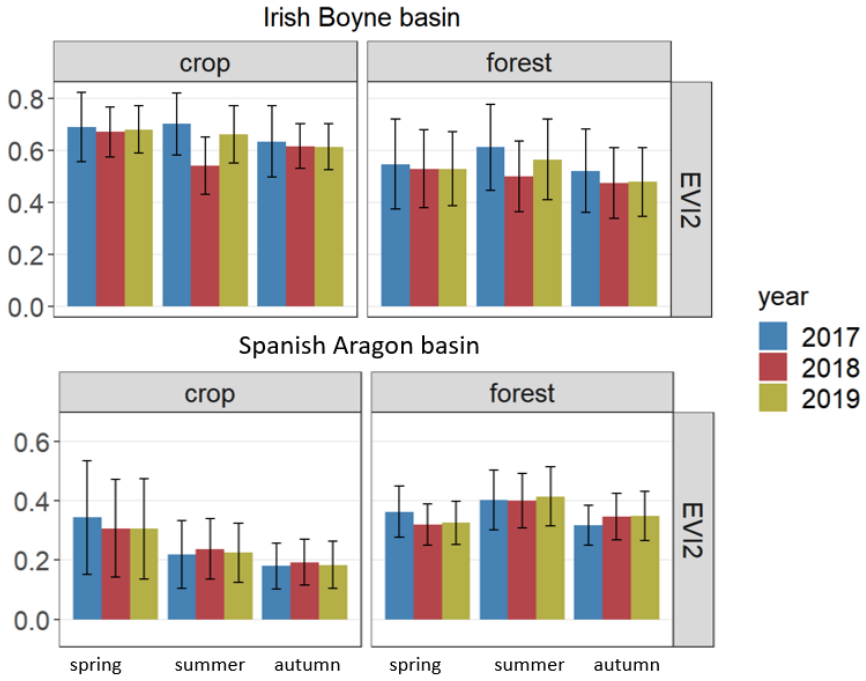
Driving the crop yield model with climate scenarios allows for estimating climate change effects on yield levels. Finally, we present a first example of such a scenario calculation for the central part of the German Elbe basin, the area with the most severe yield losses under drought conditions (−40% 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.

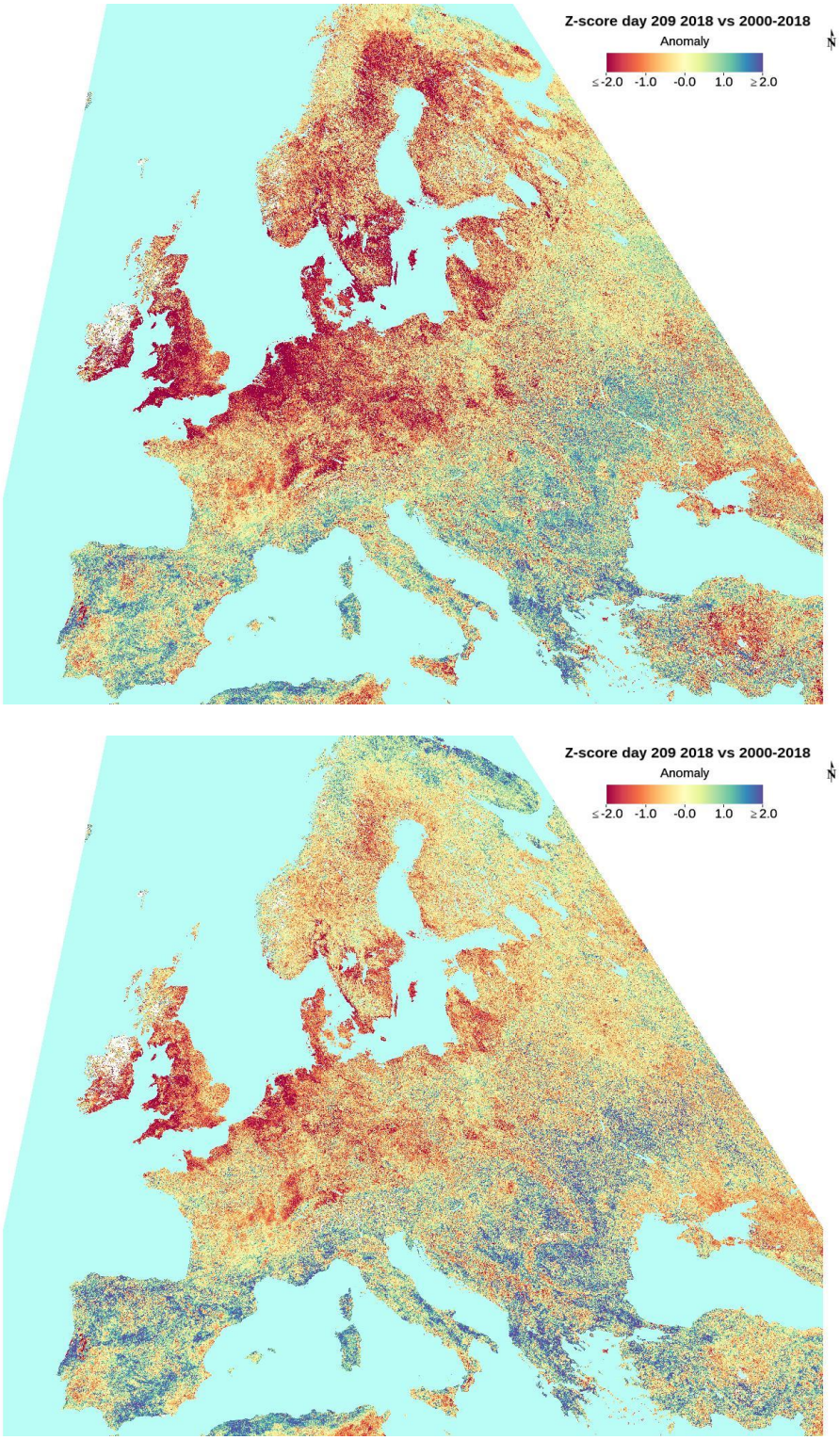
Satellite studies of drought impacts on vegetation

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.

Contact us

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

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