

This manuscript presents a global drought dataset generated through clustering-based event identification and links the resulting drought clusters with population exposure, GDP exposure, and socioeconomic impact information from EM-DAT and GDIS. The topic is important, and the attempt to connect physical drought characteristics with socioeconomic consequences is relevant for drought risk assessment. The manuscript also provides a useful workflow combining SPI/SPEI, ERA5, GDIS, EM-DAT, gridded population, and gridded GDP data. However, in my view, the manuscript in its current form does not yet provide sufficient methodological innovation or analytical rigor to justify publication as a robust global drought-impact dataset. The study largely combines existing drought indices, existing reanalysis data, existing disaster databases, and existing exposure datasets. Although the authors claim to develop a “robust clustering algorithm” and a globally consistent framework, the novelty relative to previous clustering, Lagrangian drought tracking, GDIS-based drought impact studies, and exposure-based risk analyses is not clearly demonstrated. The manuscript itself acknowledges that previous studies have already used GDIS, ERA5/ERA5-Land, drought indices, and spatiotemporal drought-cluster tracking to examine drought impacts and propagation.

We sincerely thank Reviewer 2 for the detailed and constructive assessment of our manuscript.

Our intention was not to claim that the clustering algorithm itself is novel. We agree that object based and clustering approaches have already been discussed and applied in the drought literature, as also reflected in the studies cited in our manuscript. However, we recognize that phrases such as “robust clustering algorithm” may give the impression that the clustering method is being presented as the main contribution. We will therefore revise the manuscript to avoid this ambiguity.

In the revised manuscript, we will emphasize that the main contribution is the development of a harmonized, event-level drought disaster data product that links reported drought disasters with gridded meteorological drought characteristics, population exposure, GDP exposure, and reported socioeconomic impacts, as also noted by the reviewer. This set of data novel and enables new uses of existing but previously disconnected data. Such innovation is consistent with recent ESSD data description papers that develop event based datasets linking physical hazard information with exposure and/or disaster records. For example, CLIMK-WINDS (Flynn et al., 2025) provides a new database of European winter windstorm footprints derived using a consistent footprint identification framework across several meteorological datasets, while SHEDIS Temperature (Lindersson & Messori, 2025) links temperature related EM-DAT/GDIS disaster records with subnational meteorological hazard indicators and human exposure data. Related examples from flood research include HANZE (Paprotny et al., 2018) and HANZE v2.1 (Paprotny et al., 2024), which provide event and exposure information for historical flood impacts in Europe. Our study follows a similar data product logic, but focuses on drought disasters, which comes with the additional complexity of drought being a multi-scale hazard whose exact spatiotemporal boundaries can be complex to identify. We integrate for the first time drought index derived event characteristics, population exposure, GDP exposure, and reported drought impacts in a global framework.

We agree with the reviewer that the original manuscript did not sufficiently clarify the novelty of the dataset, and we will revise the framing throughout the manuscript to make this contribution more explicit. Accordingly, we will revise the title, abstract, introduction, and methods to clarify that the clustering procedure is used as a transparent and reproducible object

detection step, whereas the novelty lies in the event level linkage between physical drought characteristics, socioeconomic exposure, and reported impacts.

The main planned changes are as follows:

- We will reframe the manuscript more explicitly as an event level drought disaster data product, rather than as a general global catalogue of all meteorological droughts or as a new drought index methodology.
- We will clarify that the novelty lies primarily in the harmonized event level linkage between EM-DAT/GDIS drought disaster records, gridded SPI/SPEI drought characteristics, population exposure, GDP exposure, and reported impacts.
- We will revise the spatial matching approach so that the main analysis uses GDIS affected area polygons, rather than relying primarily on rectangular search boxes around reported point locations.
- We will add a clearer event accounting section documenting how many events are retained, excluded, unmatched, or flagged during the harmonization between GDIS and EM-DAT.
- We will reorganize the manuscript to place the dataset description, variables, file structure, and suggested use cases more centrally, in line with the scope of ESSD.

Flynn, C. M., Moemken, J., Pinto, J. G., Schutte, M. K., and Messori, G.: CLIMK–WINDS: a new database of extreme European winter windstorms, *Earth Syst. Sci. Data*, 17, 4431–4453, <https://doi.org/10.5194/essd-17-4431-2025>, 2025.

Lindersson, S. and Messori, G.: SHEDIS-Temperature: linking temperature-related disaster impacts to subnational data on meteorology and human exposure, *Earth Syst. Sci. Data*, 17, 6379–6403, <https://doi.org/10.5194/essd-17-6379-2025>, 2025.

Paprotny, D., Morales-Nápoles, O., & Jonkman, S. N. (2018). HANZE: a pan-European database of exposure to natural hazards and damaging historical floods since 1870. *Earth System Science Data*, 10(1), 565-581.

Paprotny, D., Terefenko, P., & Śledziowski, J. (2024). HANZE v2. 1: an improved database of flood impacts in Europe from 1870 to 2020. *Earth System Science Data*, 16(11), 5145-5170.

The manuscript states that the study addresses the lack of a globally consistent framework combining spatiotemporal drought clustering with high-resolution socioeconomic exposure and impact data. The stated objectives are to identify drought “objects,” assign population and GDP exposure, and relate drought characteristics to EM-DAT impacts. However, these objectives are mostly achieved by assembling already available datasets and applying relatively standard drought-index thresholding and connected-component clustering. The authors should make much clearer what is genuinely new. Is the novelty the clustering algorithm? The event-matching strategy? The derived dataset? The weighted exposure metric? Or the joint linkage between physical drought and disaster impacts? At present, the manuscript reads more like an integration exercise than a methodological or data-product advance.

We agree with the reviewer that the original manuscript needs to distinguish more clearly between the use of established methods and the novelty of the resulting data product. Consistent with our general response above, we will clarify in the revised manuscript that the main contribution of the study is the construction of a harmonized global drought disaster dataset

that links reported drought events from EM-DAT and GDIS with SPI/SPEI derived drought footprints, event characteristics such as area, duration, severity, and detected fraction, gridded population exposure, gridded GDP exposure, and reported socioeconomic impacts. Crucially, the integration of different existing datasets enables new insights, such as inconsistencies between hazards and impacts, between exposure and impacts, different relationships between hazard and exposure distributions in different continents. All these dimensions would be difficult to investigate if the datasets were not linked and evidence the numerous additional analyses that our work enables.

The drought event identification method depends on several user-defined parameters, including target-point grouping, maximum distance threshold, buffer distance, bounding-box construction, drought-index threshold, eight-neighbor connectivity, and cluster-merging distance. The authors describe these steps, but the physical and statistical justification for these parameter choices remains weak. For example, using a rectangular bounding box around GDIS target points may artificially include regions unrelated to the reported drought event, particularly for large countries or multi-location disasters. Similarly, the use of eight-neighbor connected components is computationally convenient but not necessarily sufficient to represent real drought propagation, hydroclimatic coherence, or regional drought dynamics.

We agree with the reviewer that the role of user defined spatial parameters needs to be explained more clearly. Since drought is a complex hazard occurring on multiple spatio-temporal scales, and whose detection depends heavily on the types of impacts one is interested in, our aim is to provide a flexible tool that users can adjust to their needs. In the manuscript we have presented results for a given set of parameters, but the publicly available toolbox that accompanies the manuscript offers extensive flexibility in altering these.

In response to the reviewer's suggestion, and because the GDIS affected area polygons provide a direct spatial representation of the reported disaster footprint, we will use the GDIS affected area polygons as the primary spatial reference wherever they are available in the revised manuscript. The rectangular search option will be retained as an optional configuration and sensitivity analysis, rather than being presented as the main spatial representation.

Regarding the use of eight neighbor connectivity, we will clarify that we do not interpret this step as a physical model of drought propagation, hydrological connectivity, or regional drought dynamics. Rather, eight neighbor connectivity is used as a raster object extraction procedure to identify spatially contiguous drought pixels in the gridded SPI/SPEI fields. The temporal evolution of the drought is not diagnosed using this. Indeed, the algorithm does not implement a formal temporal object tracking algorithm that links individual clusters dynamically from one month to the next. In the revised manuscript, we will make clear that the resulting clusters represent coherent areas satisfying a given drought index, timescale, and threshold, rather than dynamically evolving drought systems. This clarification will be added to the Methods section.

The manuscript reports that larger buffer distances and less severe thresholds lead to higher matching percentages, with match rates reaching around 90% for a 500 km buffer and SPI threshold of -1, but falling below 60% under stricter parameter settings. This is an important result, but it also raises a concern: high match rates may be achieved simply by expanding the search area rather than by improving physical event identification. The authors should not interpret a higher match percentage as evidence of a better drought-event detection method without independent validation. A 500 km buffer is very large and may capture many drought-affected pixels that are only loosely related to the recorded disaster location. The manuscript

should include additional validation using well-documented historical drought events, independent drought-monitoring products, national drought reports, or regional case studies.

We agree with the reviewer that higher match percentages should not be interpreted as independent validation of better drought event detection. In the original manuscript, our intention was to use the match percentage as a sensitivity diagnostic showing how the correspondence between reported GDIS drought events and SPI/SPEI based drought clusters changes with index choice, timescale, threshold, and spatial search configuration, rather than as validation of a better drought event detection method.

We recognize that some sentences, particularly those comparing SPI and SPEI, could be interpreted as implying that a higher detection percentage indicates better performance. In the revised manuscript, we will clarify that detection percentage is not a validation score. Rather, it describes the proportion of reported disaster events for which drought index values below a chosen threshold are identified within the selected spatial and temporal window.

We will also present case studies for which clusters were or were not detected despite reported low or high impacts, and look for alternative information sources on the extent and impacts of those cases. This will help illustrate the limitations of interpreting detection percentage alone and will provide a more transparent assessment of the relationship between the physical drought signal and reported disaster impacts.

The manuscript correctly notes that EM-DAT reports disasters mainly at the country level and that GDIS provides georeferenced information only for a subset of EM-DAT events. It also identifies inconsistencies between EM-DAT and GDIS records, including cases where the same disaster number is assigned to different countries, and removes seven discrepant events using a 250 km distance threshold. However, these inconsistencies suggest a deeper uncertainty problem that is not fully addressed. The manuscript should quantify how many drought events are retained, excluded, unmatched, or only partially matched at each processing step. The authors should provide a clear event-accounting table showing the number of original EM-DAT drought events, GDIS drought entries, harmonized events, excluded mismatches, successfully clustered events, and events with valid population/GDP/impact data.

We agree that this information is essential for an ESSD data paper. We will add a new event accounting subsection, together with a corresponding table or figure, to document the complete processing chain.

In the revised manuscript, we will report:

- the number of drought records initially considered in GDIS,
- the number of drought records initially considered in EM-DAT,
- the number of GDIS events with corresponding EM-DAT records,
- the number of country mismatches identified,
- the number of events excluded or flagged.

For the harmonized GDIS and EM-DAT event set used in the revised analysis, we have retained 380 accepted events, identified 7 country mismatch events, and identified 10 GDIS events without corresponding EM-DAT records. These counts will be explicitly reported in the revised manuscript.

The manuscript calculates total population and GDP exposure by summing values over pixels that fall within drought clusters for at least one month, and then introduces a weighted exposure metric based on frequency and severity. While this is a useful first step, the current formulation is too simple to support strong conclusions about drought impacts. Exposure is not equivalent to vulnerability or realized impact. Population and GDP located within a drought cluster may not necessarily experience damage, while areas outside the cluster may still suffer indirect impacts through food systems, water infrastructure, migration, or economic networks. The manuscript should avoid implying that exposure estimates directly explain EM-DAT impacts unless vulnerability, adaptive capacity, reporting practices, and sectoral sensitivity are considered.

We agree with the reviewer. In the original manuscript, our intention was to treat exposure and impact as separate yet related quantities. Exposure was used as a descriptive measure of the population and economic activity located within the detected drought affected areas, and these exposure estimates were then compared with reported impacts from EM-DAT. This can then provide an event-level picture of vulnerability. While it is true that drought impacts can extend beyond the direct drought-affected region, the fact that EM-DAT reports impacts at national level limits this dimension (e.g. the remote impacts on international food trade, international economic networks or international migration would not be captured). Moreover, as the Reviewer correctly notes, only a part of the exposed population and GDP is typically damaged by the hazard(s) it is exposed to. We thus argue that cases for which impacts exceed exposure are not impossible, but should at the very least be regarded as suspect. To conclude, we did not intend to imply that exposure alone explains vulnerability or realized drought impacts, but we nonetheless believe that a comparison of exposure and impacts can provide some informative insights on these different components.

We recognize that some wording in the original manuscript may have been too strong, particularly where weighted exposure was discussed in relation to risk. We will therefore revise the exposure and impact sections to use more cautious wording, and highlight the caveat of potential remote impacts which do not find correspondence in our direct exposure analysis.