

Response to Community Comments CC1 and CC2

Manuscript egusphere-2026-4014: "LESSONS report: Fine-scale representation of consecutive dry days"

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We thank Sivarajah Mylevaganam for the careful reading of our manuscript and for the two community comments; CC2 contains the same points as CC1 in the form of a supplement, so we answer both together. The comments led us to correct the definition of meteorological drought and the use of 'rainfall', to describe the nesting of COSMO-CLM, to report the value range over Germany, and to clarify the display of missing data in Fig. 1.

Reviewer comments are reproduced in dark red italics. New or revised manuscript text is quoted in blue; line numbers refer to the initial preprint. LESSONS Reports are limited to about 2000 words in the main text.

General assessment

Natural disasters have been occurring since the inception of this planet, manifesting in various ways. Among these, drought stands out as a unique phenomenon, demonstrating to the Earth's inhabitants how the absence of a single drop of water can devastate humanity. Its widespread implications span multiple domains, ranging from critical dehydration in human biology to severe disruptions in global agricultural food production.

Drought can be subdivided into categories based on the specific field or objective of interest. For example, it is commonly classified as surface water drought, groundwater drought, or meteorological drought. Although these subdivisions share the root term "drought," their operational contexts and foundational definitions differ significantly based on how they are perceived and reported.

In this research, the authors focus specifically on meteorological drought, which they define based on the ETCCDI (the maximum number of consecutive dry days with precipitation below 1 mm within one year) framework and characterize as the absence of rainfall. Although this constraining threshold of 1 mm is not fully aligned with the measurement precision of modern instruments like rain gauges and other advanced precipitation measurement systems, the authors guide the reader through four distinct pathways to comprehensively investigate meteorological drought in Germany. These pathways utilize various datasets across different spatial resolutions. Finally, the authors draw multiple conclusions based on the 2018 rainfall events in Germany, as they consider this specific year to be the best reflection of severe drought conditions across Europe.

Based on the current version of this research article, the following points are brought forward for consideration:

Response: Thank you for the summary. We would like to clarify two points of it. First, the 1 mm threshold is the ETCCDI definition of a dry day (Zhang et al., 2011). It lies well above the resolution of rain gauges (0.1 mm), so that the index does not depend on the detection of trace amounts, and we tested thresholds of 0.1 and 2 mm (Fig. S2), which yield qualitatively similar patterns. Second, we do

not consider 2018 the best reflection of drought conditions in Europe, but a year with severe drought conditions (Blauhut et al., 2022), and the conclusions are not restricted to 2018: Fig. 4 covers 30 years of COSMO-CLM, and Fig. S1 shows three further years from an independent CPM. We will also show in the revised manuscript that 2018 is the year with the strongest effect among the 30 years, so it is a well-suited example.

Comment #1

Comment #1: Definition of meteorological drought

1. Lines 26–27: The authors state that meteorological drought—defined here as the absence of rainfall—can induce a cascading effect leading to agricultural, surface water, and groundwater droughts. While the authors cite a manuscript to support this claim, the definition provided contradicts the consensus on meteorological drought in current literature. A clear distinction between "rainfall" and "precipitation" must be established to ground the definition used in the current version of the manuscript.

Response: We agree, and thank you for spotting this. Meteorological drought is commonly defined as a deficit of precipitation relative to normal conditions over a given period, not as the absence of rainfall (Van Loon and Van Lanen, 2012). We corrected the sentence and replaced ‘rainfall’ by ‘precipitation’:

New text (Introduction, l. 26–27):

"Meteorological droughts, i.e. periods with a deficit of precipitation relative to normal conditions (Van Loon and Van Lanen, 2012), can thereby induce a cascade towards agricultural, surface water and groundwater droughts (Liu et al., 2023)."

We also replaced ‘rainfall’ by ‘precipitation’ at l. 130 (“intervening areas of more intense precipitation”). The term ‘rain gauge’ is kept, as it is the established name of the instrument.

Comment #2

Comment #2: Rainfall versus precipitation in the data sets

2. The study's analysis relies on the ERA5 reanalysis, convection-permitting model (CPM) simulation, the radar-based precipitation reanalysis RADKLIM, and HYRAS station-based gridded rain gauge measurements [Lines 46-50]. If one considers radar observations, for instance, these datasets capture total atmospheric precipitation rather than liquid rainfall exclusively—a fact correctly indicated by the dataset names themselves (e.g., RADKLIM precipitation reanalysis). Therefore, attempting to align a strict "absence of rainfall" definition [Line 26] with datasets that measure total precipitation suggests a fundamental oversight. The authors must address these hydrological nuances rather than applying these terms interchangeably without considering their underlying technical definitions.

Response: We agree that the terms must not be used interchangeably, and the only inconsistency was the wording at l. 26, which we corrected (see C1). All four data sets provide total precipitation,

liquid and solid: total precipitation in ERA5 and COSMO-CLM, gauge-measured precipitation in HYRAS, and gauge-adjusted radar precipitation in RADKLIM. CDD is defined on daily precipitation (Zhang et al., 2011) and is therefore consistent with all four data sets. In addition, solid precipitation is of minor relevance for the results: in COSMO-CLM, the longest dry spell of 2018 lies entirely between April and October at 93 % of the grid cells over Germany.

Comment #3

Comment #3: The cited reference

3. Moreover, given that the authors cite a specific manuscript to justify this unusual definition of meteorological drought, it becomes the responsibility of the handling editor to review the cited work [Line 27]. It is critical to verify whether that referenced study actually supports the authors' statement or if it has been misinterpreted in the current manuscript.

Response: We corrected the inconsistent wording, replacing 'rainfall' by 'precipitation'. This is also what Liu et al. (2023) use.

Comment #4

Comment #4: Nesting of COSMO-CLM in ERA5

4. Lines 46–47: The authors state that the convection-permitting simulations of COSMO-CLM are driven by the boundary conditions of ERA5 at a 3 km resolution. However, based on the current version of the manuscript, ERA5 is natively produced at a spatial resolution of approximately 31 km, whereas COSMO-CLM operates at 3 km [Lines 46–47]. It is currently unclear how the 31 km ERA5 data was processed or downscaled to serve as boundary conditions for the 3 km CLM simulation.

Given that COSMO-CLM is one of the four core datasets used to investigate meteorological drought in Germany, the authors must provide a few clarifying lines to explicitly explain the nesting or downscaling procedure implemented during the production of this dataset. Furthermore, this methodological clarification should be contextualized alongside lines 31–33, noting what has been widely reported in the literature: that ETCCDI extreme climate indices are largely smoothed out or lost at coarser resolutions.

Response: Thank you, we will describe this briefly. For the ERA5 period, the HoKliSim-De evaluation run was nested in one step directly into the 3 km domain (Rybka et al., 2023): COSMO-CLM (version COSMO-CLM5-0-16) solves the atmospheric equations on a grid of 0.0275° (about 3 km, 461 × 481 grid cells; analysis domain: 415 × 423 grid cells), the ERA5 fields are interpolated to the lateral boundaries of this domain and updated every hour, and the model generates the fine-scale atmospheric fields, including precipitation, inside the domain itself, with deep convection resolved explicitly and only shallow convection parameterised. The precipitation of COSMO-CLM is thus not an interpolation of ERA5 precipitation, which is why it can show structures that ERA5 cannot. We will add this to the data description, brief due to the size restrictions of a LESSONS report:

New text (Sect. 2, l. 46–47):

"2) convection-permitting simulations of COSMO-CLM at 3 km, nested directly into ERA5, which provides the lateral boundary conditions every hour (Brienen et al., 2022; Rybka et al., 2023), ..."

Regarding the link to l. 31–33: as requested by Reviewer #1 we will show directly how CDD changes when the COSMO-CLM precipitation is aggregated to coarser grids. There, the mean CDD over Germany decreases from 26.8 days at 3 km to 24.5 days at 30 km and 23.0 days at 99 km.

Comment #5

Comment #5: Value range and colour bar of Figure 1

5. In the text, the authors state that CDD values span a wide range of 7 to 100 days across the datasets (Line 68). However, the colorbar scale reported in Figure 1 is limited to a maximum value of 60. This artificial constraint conceals the exact geographic locations where the highest CDD values (above 60 days) occur across the datasets. Therefore, the scale in Figure 1 should be adjusted up to 100 days to align with the text statement in Line 68 and properly reflect the full spatial variability of extreme values.

Response: Thank you, the range in l. 68 was misleading. It referred to the entire fields of the data sets, including areas outside the German borders 1 such as the Alps (minimum of 7 days in ERA5) and the lateral boundary zone of the COSMO-CLM domain in France, where the maximum of 102 days is located. In the largest common domain of all data sets (sampled on the 3 km grid, Table S1), the CDD ranges from 12 to 41 days in ERA5, 12 to 68 days in COSMO-CLM, 13 to 55 days in HYRAS and 11 to 56 days in RADKLIM, with the 1st to 99th percentiles of all data sets between 15 and 50 days. Values above 65 days, the end of the colour bar, occur at 7 of 36,634 COSMO-CLM grid cells (0.02 %). No grid cell of ERA5, HYRAS or RADKLIM exceeds 65 days in this domain.

We therefore prefer to keep the colour scale, which spans the range of more than 99.9 % of the values over Germany and resolves the fine-scale structure that is the subject of the paper, whereas a scale up to 100 days would compress this range into the lower two thirds of the colour bar. The colour bar ends with an arrow, so that values above 65 days are shown in the darkest colour and remain visible. We will modify the text and the caption, and add Table S1 for the full statistics:

New text (Sect. 3, l. 67–68):

"Within the common domain of all data sets, CDD values range from 11 to 68 days (Table S1)."

New text (caption of Fig. 1):

"Values above 65 days, which occur at fewer than 0.02 % of the grid cells over Germany, are shown in the darkest colour; grey areas indicate no data."

Comment #6

Comment #6: North-western boundary region in Figure 1

6. A closer examination of the subplots in Figure 1 reveals stark discrepancies in the areas just outside the primary domain of interest (the digitized polygon boundary), particularly toward the Northwest (NW) region. Because the colorbar scale is currently capped at 60, it is difficult to trace the exact numerical variation in these boundary grid cells. However, the coarser-resolution datasets—ERA5 (31 km) and COSMO-CLM (3 km)—appear to exhibit exceptionally high values in this zone, likely reaching or exceeding 60 days. In sharp contrast, the finer-resolution datasets, HYRAS (1 km) and RADKLIM (1 km), show virtually zero CDD in the exact same peripheral region, appearing completely white. The authors need to address what physical mechanism, data processing step, or domain-masking artifact has introduced this pronounced, distinct variation among the datasets in the NW boundary region.

Response: Thank you for this careful observation; the figure was ambiguous. The white areas in Fig. 1c and 1d are areas without data, not areas with zero CDD: the HYRAS data used here cover Germany only, and RADKLIM covers the German radar composite, which extends slightly beyond the border. The lowest CDD over Germany is 11 days in any of the four data sets, and within Germany, the north-western region (5.5–7° E, 50.5–52° N) has a mean CDD of 25.5 days in HYRAS and 27.1 days in RADKLIM. In the revised Fig. 1, areas without data are shown in grey and the caption states this (see C5).

ERA5 does not show exceptionally high values in this region (mean 20.9 days, maximum 24 days in the same box); its highest values occur over the North Sea. COSMO-CLM, however, does simulate a pronounced dry anomaly over Belgium, the Netherlands and western Germany (mean of 41.1 days inside Germany and 50.6 days outside Germany in the same box, maximum 76 days). This is not a boundary or masking artefact: this region lies more than 270 km from the lateral boundary of the COSMO-CLM domain. It reflects the free evolution of precipitation inside the CPM domain, which does not place the few precipitation events of 2018 at the observed locations (l. 74–76), and it is one reason why we do not evaluate CDD magnitudes grid cell by grid cell. We add this in the caption of Fig. 1:

New text (caption of Fig. 1):

"COSMO-CLM simulates a dry anomaly over the Benelux countries and western Germany, which is absent from ERA5, HYRAS and RADKLIM."

References added to the manuscript

Van Loon, A. F. and Van Lanen, H. A. J.: A process-based typology of hydrological drought, Hydrol. Earth Syst. Sci., 16, 1915–1946, <https://doi.org/10.5194/hess-16-1915-2012>, 2012.