

We thank the reviewers for their feedback and wish to address their remaining concerns. Please find hereafter our replies in italics shaded in blue.

Anonymous Referee #3

nominated 12 Aug 2025, accepted 13 Aug 2025, report 26 Aug 2025 [Report #2](#)

I am still concerned about the definition of CHD. The CHD is defined as Tmax exceeding its threshold, while PEI30, PEI60, or PEI180 falls below the 1% threshold. However, this raises two questions:

We acknowledge the reviewer's concern regarding the overestimation and underestimation of compound hot and dry events. However, we are convinced that our approach is a good compromise, even if not perfect. Our method successfully detected and matched the referenced historical events, demonstrating strong agreement and confirming that the approach is both realistic and applicable.

1) A daily Tmax exceeding its 99% threshold indicates only a one-day hot weather event. In contrast, PEI30, PEI60, or PEI180 represents the averaged water balance over the past 30, 60, or 180 days, which reflects a long-term phenomenon. This creates a mismatch when combining hot and dry conditions. For example, consider an extreme case: one day records an extremely high temperature accompanied by a heavy storm. However, if the previous 29 days had absolutely no rainfall, the event may still be detected as CHD due to the preceding dry conditions. This may overestimate the frequency of CHD events, as it may capture situations where extreme heat and dryness do not truly overlap in time.

Drought and heatwaves typically occur at different time scales. The drought conditions are always assessed on longer time scales, typically months or years. Flash drought of less than a month have however also been studied, but they are not the focus of this study as the major effects on vegetation productivity occur through longer-term water deficits. A heavy storm occurring on a single day will not necessarily drastically change the underlying drought conditions for the vegetation, especially not for (deeper rooting) trees and not necessarily proportional to the intensity of precipitation, as heavy precipitation will most probably incur a lot of runoff which won't be available for uptake to the vegetation (However, this out of this study's scope). Drought is not necessarily defined by the complete absence of precipitation but by the relative deficit thereof. Also, a heavy storm will most probably make the maximum temperature drop on the day of the precipitation event or the next (see for example Fig.3). The heat criterion might have been a combination of both Tmax and Tmin to avoid those cases completely. We did give this issue thought in our experimental design, which is why our criteria for the definition of the CDH event require that at least three consecutive days are hot and dry, lowering the chance of encountering such cases.

2) If the hot event does not occur exactly on the 30th day, but instead happens within the preceding 1st to 29th day, how should such an event be characterized? Such an event might not be captured under the current definition

Indeed, our detection method requires that the average reference evaporative stress (PEI) over the target day and the previous 29 days (respectively 89 or 179) be under the 1% of its distribution. Such an accumulation period is common in drought definition: a few relatively dry days could make a flash drought, but this is not the focus of this study. Again, Figure 3 illustrates this well: a heatwave occurred at the end of June 2021 near Lytton, British Columbia, while none of the PEI was under its threshold. PEI_30 only became extreme around the 15th of July. A few hot days occurred at the beginning of August, but are not part of a labelled event, because the heatwave didn't last at least three consecutive days. Only from the 11th of August were the three criteria met: extreme heat, extremely low PEI (both 30 and 90 in this case) and at least three consecutive days of both previous criteria. Those four days are hence part of the labelled event 130727 in our database, whose statistics can be retrieved with the following Julia code snippet.

```
``julia
using YAXArrays, Zarr, Dates, DataFrames
import CSV
labelpath =
"https://s3.bgc-jena.mpg.de:9000/deepextremes/v4/mergedlabels_ranked_pot0.01_ne0.1_cmp_S1_
T3_1950_2023.zarr"
labels = Cube(zopen(labelpath))
mylabel = labels[latitude=Near(50.23), longitude=Near(-121.59+360), Ti=At(
Date("2021-08-11"))].data[:]
tmppath =
download("https://s3.bgc-jena.mpg.de:9000/deepextremes/v4/MergedEventStats_landonly_int.csv")
cdhstats = CSV.read(tmppath, DataFrame)
show(stdout, MIME("text/csv"), filter(:label => x-> x==mylabel, cdhstats))
```
"label","start_time","end_time","longitude_min","longitude_max","latitude_min","latitude_max","t
2mmax_mean","t2mmax_min","t2mmax_max","pei_30_mean","pei_30_min","pei_30_max","pei_9
0_mean","pei_90_min","pei_90_max","pei_180_mean","pei_180_min","pei_180_max","heat","drou
ght30","drought90","drought180","compound","land_share","inth","intd30","intd90","intd180","vol
ume","duration","area"
130727,"2021-08-11T00:00:00","2021-08-15T00:00:00",237.75,244.5,49.25,52.5,28.5420693038134
9,20.479685149327395,33.92608105757847,-1.7460892921990534,-2.6781122637298655,-0.28576
391032335413,-0.9112429926574818,-2.37201260008702,0.9771429682567515,-0.0621664542635
9538,-1.493845561964741,1.8248299548958824,100.0,59.82,70.94,49.85,100.0,100.0,165.8145904
3406002,73.9858421244105,119.14148039770703,96.5862652613458,320.76162123680115,"5
days",64.15232424736023
```

|               |                     |
|---------------|---------------------|
| label         | 130727              |
| start_time    | 2021-08-11 00:00:00 |
| end_time      | 2021-08-15 00:00:00 |
| longitude_min | 237.75              |
| longitude_max | 244.5               |

|              |                |
|--------------|----------------|
| latitude_min | 49.25          |
| latitude_max | 52.5           |
| t2mmax_mean  | 28.5420693     |
| t2mmax_min   | 20.47968515    |
| t2mmax_max   | 33.92608106    |
| pei_30_mean  | -1.746089292   |
| pei_30_min   | -2.678112264   |
| pei_30_max   | -0.2857639103  |
| pei_90_mean  | -0.9112429927  |
| pei_90_min   | -2.3720126     |
| pei_90_max   | 0.9771429683   |
| pei_180_mean | -0.06216645426 |
| pei_180_min  | -1.493845562   |
| pei_180_max  | 1.824829955    |
| heat         | 100            |
| drought30    | 59.82          |
| drought90    | 70.94          |
| drought180   | 49.85          |
| compound     | 100            |
| land_share   | 100            |
| inth         | 165.8145904    |
| intd30       | 73.98584212    |
| intd90       | 119.1414804    |
| intd180      | 96.58626526    |
| volume       | 320.7616212    |
| duration     | 5 days         |
| area         | 64.15232425    |

As a reminder, this is how the caption of Figure 3 reads:

*Heat and drought indicators during a reported compound dry and hot extreme event in the summer of 2021 in British Colombia. Panels show (a) the maximum daily temperature, (b) the daily precipitation and reference evapotranspiration, (c) the three drought indicators (PEI) and (d) the Discrete Extreme Occurrences (DEO). A first heatwave starting 25-06-2021 is not associated with a drought. A second (30-07-2021) and third (03-08-2021) heatwaves are associated with extremely dry conditions but last only two days each. A fourth heatwave starting 11-08-2021 and lasting four days is associated with extremely dry conditions (PEI\_30 and PEI\_90) and is hence part of a labelled event from the proposed database.*

We've added the following to the existing discussion (current manuscript excerpts in squared brackets):

[The global event detection of compound dry and hot extreme events faces the difficulty of dealing with processes that happen at different time scales. ]

[...]

[The framework presented here concentrates on detecting and labelling droughts and heatwaves and their compound occurrence based on daily meteorological data. ]

Our approach relies on daily data and defines CDH at daily scale, but using 30, 90 and 180 days accumulation periods for assessing dry conditions. Hence, a DEO combines heat on the day with accumulated water stress, allowing to reconcile the differing time scales of drought and heat. Flash droughts are not a focus of this study. Only three consecutive DEOs make it to a labelled CDH, alleviating the overestimation of CDH events.

[The resulting labelled CDH events can be used to analyze trends at regional, continental and global scales and to drive further research into the impacts of such events on ecosystems, specific species or society.]