

We thank the reviewers for their feedback and suggestions to improve the manuscript. Below, we respond to each comment point by point. The reviewer's comments are in **black**, our responses in **red**. At the end of the responses, we list the new references which are not listed in the submitted manuscript.

Reviewer 2:

Overview

Lohman et al. aim to investigate the statistical relationship between blocking and extreme events in Germany, using reanalysis datasets and CMIP6 model outputs. They quantify the odds ratios of three extremes (heat wave, heavy precipitation, and calm) regarding atmospheric blocking. They also argue that the relationship between blocking and the three extreme types changes only moderately.

While the topic itself is societally relevant and falls within the journal's general scope, I find that the study suffers from potentially quite strong sensitivity of the results to the chosen grid point and a lack of mechanistic interpretation. Although the journal (Natural Hazards and Earth System Sciences) publishes studies on assessments of natural hazards, the present study primarily presents statistics that are likely highly dependent on the selection of grid points, without sufficient dynamical and mechanistic discussions.

Therefore, I am unable to recommend this manuscript for publication in Natural Hazards and Earth System Sciences.

Major comments

I am seriously concerned about the robustness of the results, as the authors' choice of the single grid point appears arbitrary and may not adequately represent Germany. This study provides numerous statistics and numbers, all of which heavily rely on the validity of the choice of the data point. Figure 5, which serves as a summary plot, can therefore be quite misleading if the choice of the data point is not proven to be valid. The authors need to justify this choice more rigorously or, preferably, to base their analysis on a spatially averaged region or multiple grid points representing Germany or relevant subregions. This would substantially enhance the robustness and credibility of the results.

In recent decades, several extreme events related to blocking hit Central Europe (e.g. heatwaves 2003 and 2018, flood events in 2013 and 2021, calms in winter 2024/25). We want to quantify the relationship between blocking and extreme events and selected Germany as an example target area. Lhotka and Kysely (2015) and Lhotka and Kysely (2022) show that heatwaves are large-scale phenomena affecting several countries concurrently. The spatial extent of heatwaves is typically several million square kilometres (Lhotka and Kysely, 2022). Grams et al. (2017) show that weak winds occur widespread and quite homogeneously within high pressure systems. Thus, for heatwaves and calms, we picked a point in the centre of Germany (51°N, 10°E) to represent Germany and the surrounding area. Furthermore, we defined all extreme events based on percentiles to consider grid resolution and orographic effects. Heavy precipitation is spatially more inhomogeneous than heatwaves and calms:

Hofstätter et al. (2018) show different weather regimes causing heavy precipitation in Central Europe. Depending on the investigated region in Central Europe, different weather regimes cause heavy precipitation events. Hofstätter et al. (2018) show that many heavy precipitation events in Western Germany are related to low pressure systems over the Atlantic. Many events in Eastern Germany are related to so called Vb-cyclones, a cyclone type moving from the central Mediterranean over the eastern Alps northward. With respect to these differences, we differentiate between heavy precipitation in Western and Eastern Germany. We think that a point represents Western, respectively Eastern Germany because we analyse 24-hour precipitation which reduces the impact of small-scale convective precipitation on the statistics compared to hourly precipitation. Heavy precipitation on daily timescale is mostly related to synoptic scale precipitation which affects at least several thousand square kilometres (Szemkus et al., 2025). We selected the grid points along 51°N because this is approximately in the centre of Germany with respect to north-south direction. We will add these arguments to the manuscript to clarify our selections.

To be honest, this manuscript focuses too heavily on statistical relationships without sufficient dynamical and mechanistic interpretations and discussions. I am left with many “why” questions. Although the authors touch on potential mechanisms for the relationship between blocking and extremes, their arguments remain speculative, only referring to previous literature. The authors might want to add their own analyses on other variables to compare with previous studies if needed. Such mechanistic discussions would enhance the robustness of the results.

The fundamental mechanisms behind the extreme events are discussed in existing literature. For example, it is well known that heatwaves in summer are related to strong solar insolation and subsidence within high pressure systems and that soil desiccation enhances heatwaves. We will mention the existence of several studies dealing with the mechanisms between blocking and extreme events already in the introduction and give an example. For further mechanisms, we will refer to the discussion section to avoid repetitions in introduction and discussion. We will add that the existing mechanistic discussions are a motivation for our statistical analysis to show that the mechanisms have statistical significance. Furthermore, we will add some mechanistic discussions regarding the relationship between blocking and extreme events in the climate simulations to explain differences between reanalyses and climate simulations. For example, Talib et al. (2023) found that the CMIP6 simulations underestimate the soil moisture-atmosphere feedback. Reduced soil moisture is an important driver of strong heatwaves like 2003 and forced by blocking (Miralles et al., 2014). Consequently, an underestimation of the soil-moisture-atmosphere feedback results in an underestimation of the link between blocking and strong heatwaves. An own analysis of mechanisms would go beyond the scope of this study.

In addition, Section 4 is overly long and needs to be more structured. I recommend moving the mechanistic discussions on each extreme to Section 3.

We will check this section for possibilities to shorten it and to structure it more. However, we think that the mechanistic discussions should be done in the discussion section and not in the results section because it *discusses* the results which takes existing literature into account. The mechanistic discussion shall explain the statistical relationships and why climate simulations disagree with the reanalyses. In our opinion, this should be part of the discussion section.

Other comments

Please clarify which ensemble members are used for the selected models.

We will add a table listing the member of each model.

L133: What is the meaning of “subjectively identified based on the maxima”?

This expression means that we used the spatial patterns of the conditional frequencies in the Figures 1-4 to identify regions in Europe where the statistical relationship between blocking and extreme events is most pronounced. We defined the domains shown in the Figures 1-4 around these regions to apply the 50% criterion explained in lines 134ff. The identification of these domains was done “by eye”, therefore subjectively. With reconsidering the presentation of the results as suggested by reviewer #1, we will replace the tables by figures showing the multi-model means of reanalyses and CMIP6 simulations. Therefore, we will not apply this 50% criterion anymore and we will calculate area means only of the odds ratio at the end. This results in a reformulation of several paragraphs in section 2.3 including the lines around L133.

L159: Please correct the part “all reanalyses respectively CMIP6 simulations”.

We will reformulate this sentence.

How do the authors define extremes in ssp585? Do they use the same threshold as in historical? What are the changes in the mean frequency of blocking and extremes in their analysis?

The thresholds to define extremes in SSP5-8.5 are identical to the thresholds in the historical period to enable a direct comparison between both periods. This results in an increase of extreme event days, especially in the number of the heatwave days. Blocking frequency changes only moderately and with seasonal differences as presented in Lohmann et al. (2024).

References:

Lhotka, O. and Kyselý, J. (2015). Characterizing joint effects of spatial extent, temperature magnitude and duration of heat waves and cold spells over Central Europe. *Int. J. Climatol.*, 35: 1232-1244, <https://doi.org/10.1002/joc.4050>.

Lhotka, O., & Kyselý, J. (2022). The 2021 European heat wave in the context of past major heat waves. *Earth and Space Science*, 9, e2022EA002567, <https://doi.org/10.1029/2022EA002567>.

Szemkus, S., Buschow, S., and Friederichs, P. (2025). Revealing the structure of precipitation extremes: a spatio-temporal wavelet approach, *EGUsphere* [preprint], <https://doi.org/10.5194/egusphere-2025-5922>.

Talib, J., Müller, O.V., Barton, E.J. *et al.* (2023). The Representation of Soil Moisture-Atmosphere Feedbacks across the Tibetan Plateau in CMIP6. *Adv. Atmos. Sci.* **40**, 2063–2081, <https://doi.org/10.1007/s00376-023-2296-2>.