EGUsphere, referee comment RC2
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Comment on egusphere-2022-1478

Anonymous Referee #2

Referee comment on "Persistent warm and cold spells in the Northern Hemisphere extratropics: regionalisation, synoptic-scale dynamics and temperature budget" by Alexandre Tuel and Olivia Martius, EGUsphere, https://doi.org/10.5194/egusphere-2022-1478-RC2, 2023

The authors investigated processes leading to warm and cold spells in the extratropical northern hemisphere and identified three main drivers responsible for these events: (i) upstream blocking, (ii) downstream blocking, and (iii) subpolar troughs. In addition they analysed the relative importance of advection, vertical motion, and diabatic processes for temperature extremes in the lower planetary boundary layer and the 850-hPa level, and identified regions influenced by a similar large-scale circulation. The manuscript is well-written and the figures are of high quality. However, I have significant concerns about the methods, the implication of the results, and the comparison with the existing literature. In my opinion, the study does not address the research question stated in the title.

Major comments:

- In the Introduction, the authors identify two gaps in the literature on the processes responsible for warm and cold spells: (i) persistence and (ii) spatial dependence. With respect to the first gap (persistence), what can we learn meteorologically from longer lasting events that we don’t already know from the existing literature? There is already a lot known on driving factors for heat and cold waves. I am not arguing that it is not interesting to look at the persistence, but the authors insufficiently motivate why it could be interesting to look at persistent events (apart from impacts). In addition, a minimum duration of three days does not exclude long-lasting events, e.g. in Zschenderlein et al. (2019), a heat wave with a duration of more than 40 days was included in the analysis. It is therefore not true that previous work generally focused on short-lived events only, as the authors claim. With respect to the second gap (spatial dependence), the authors argue that the recent literature looked at arbitrary regions and mixed up areas where warm or cold spells are shaped by different physical processes. They are by far not arbitrary in the recent literature, either regions are motivated by impacts (which is perfectly fine and definitely not arbitrary) or by different climates (e.g. humid vs. dry climate). There are also studies looking at the different physical processes in a region, e.g. Sousa et al. (2018, Fig. 5). It is therefore not overlooked that in one region the processes can differ regionally.
- The study promises a lot to provide new insights into the persistence and spatial dependence of warm and cold spells. However, both aspects are not really quantified in the study. I detail my comments below:

  - Persistence: Sections 4 and 5 are believed to address this research question. However, these sections rather analyse synoptic conditions during warm and cold spells (which is nicely done) and identify three atmospheric drivers (upstream blocking, downstream blocking, subpolar troughs). Many studies already investigated the position of the block relative to the high/low temperature extreme at the surface (e.g. Pfahl and Wernli 2012, Pfahl 2014, Bieli et al., 2015, Santos et al., 2015, Sousa et al. 2018, Zschenderlein et al., 2019). The authors should therefore make the new findings more clear. While I find the synoptic analysis very nice, I don't understand what this has to do with persistence. And this is the main aspect of the paper (at least it is stated in the title). For example, how important is the position of the block relative to the warm/cold spell with respect to the persistence in comparison to a heat/cold spell of about 5 days? I think the authors try to discuss the persistence aspect in Section 5, but not really successful. They are rather speculating about the role of blocks, RRWPs, land-atmosphere feedback, and subpolar troughs (with results from the existing literature and not their own) and not quantifying the importance of these processes with respect to persistence.
  - Spatial dependence: I think the authors want to address this research question with the regionalisation approach (Fig. 3). But in the end, they summarise all regions into three categories (and they don't describe how they do it, see also my minor comments). What is the added value of the regionalisation? What can we learn from it? What do the different colors in Fig. 3 imply meteorologically? In my view, Figure 3 is insufficienty discussed.
- I am not convinced by the method for the identification of persistent warm and cold spells. While I understand that you incorporate the days prior to the spells to investigate the onset, I do not understand why your analysis window ends with the peak temperature anomaly. What if this anomaly is reached already very early during the warm/cold spell and high/low temperatures still persist after that peak? And for the quantile regression I would exclude grid points in the tropics beforehand, because a low Z500 variability in this area is no surprise.
- The results of this study are not set into context with the existing literature. An attempt is made in Sections 5 and 6.2, but it is not clear what new knowledge is introduced by the study.

Minor comments:

L5-10 (Abstract): All listed processes (blocks important precursors of warm and cold spells, location of the blocks, recurrent Rossby waves, land-atmosphere feedbacks) are already described in many papers (see list in major comment 2) or in a new review paper by Domeisen et al. (2022, „Atmospheric processes‟ section; the paper was probably not yet published at the time the authors submitted to WCD).

L65: Does this mean that you first subtract the mean and divide by the standard deviation?

L66-68: Why do you use different methods for the trend removal of T2M and Z500?

L70: Is the persistency criterion of 4 days valid for an individual grid point or for the whole cyclone mask?

L70-80: Should be moved to the methods section.

L84: Is the percentile based on daily or 3-weekly values? And please do not use different words for the same method (normalise, rescaled)

L89: Why non-overlapping 3-week intervals?

L105: How sensitive are your results with respect to the DR threshold?

L112: What is a silhouette coefficient?

L129: Why not using the back-extension of ERA5?

L135: Is the decay phase of the event not interesting?

L143: median point – do you mean centroid?

Figure 1: I don't understand the values on the y-axis. Is it normalised with the 95th percentile? I also do not understand why the grey shaded area goes from approximately day 11 to 31.

Section 4.1: How have you identified the three main groups?

Figure 5 (and others): Mark the centroid of the regions. Add wind directions or Z500 mean values.

General remark to the composites: I personally think that compositing can be quite dangerous here, because you are averaging over areas with different sizes and shapes. Can you comment on that?

L225: Be careful because you are mixing land and ocean grid points (see red colours in Fig. 4).

Figure 6: The scale in Fig. 6c differs from Fig. 5c!

L250: These results are in line with Zschenderlein and Wernli (2022).

Section 4.4 and Figure 12: I am not able to follow because you haven't described the R-metric sufficiently.

L290: remove the second „is"

L310: This agrees with a host …. —> ok, but where is the new knowledge regarding the persistence?

L312-313: This is probably also true for events on the shorter time scales.

L318: remove half sentence in brackets at the end of the line.

L348-350: This is not clear to me. Increasing surface heat fluxes would imply diabatic heating, but we see diabatic cooling in Fig. 11f. Radiative cooling is typically dominant in the mid- to upper-troposphere.

L351-352: What can we learn from this sentence?

Section 5.4: You discuss how a subpolar trough develops. But I don't see how you discuss subpolar troughs and their connection to persistence of warm and cold spells.

Section 6.1: A matter of taste, but the discussion of Fig. 3 appears quite late in the study. I would prefer to discuss the results earlier.

L383: Acronym S2S not introduced

Literature:

Bieli, M., Pfahl, S. and Wernli, H. (2015), A Lagrangian investigation of hot and cold temperature extremes in Europe. Q.J.R. Meteorol. Soc., 141: 98-108. https://doi.org/10.1002/qj.2339

Domeisen, D.I.V., Eltahir, E.A.B., Fischer, E.M. *et al.* Prediction and projection of heatwaves. *Nat Rev Earth Environ* **4**, 36–50 (2023). https://doi.org/10.1038/s43017-022-00371-z

João A. Santos, Stephan Pfahl, Joaquim G. Pinto & Heini Wernli (2015) Mechanisms underlying temperature extremes in Iberia: a Lagrangian perspective, Tellus A: Dynamic Meteorology and Oceanography, 67:1, DOI: 10.3402/tellusa.v67.26032

Pfahl, S., and Wernli, H. (2012), Quantifying the relevance of atmospheric blocking for co-located temperature extremes in the Northern Hemisphere on (sub-)daily time scales, *Geophys. Res. Lett.*, 39, L12807, doi:10.1029/2012GL052261.

Pfahl, S.: Characterising the relationship between weather extremes in Europe and synoptic circulation features, Nat. Hazards Earth Syst. Sci., 14, 1461–1475, https://doi.org/10.5194/nhess-14-1461-2014, 2014.

Sousa, P.M., Trigo, R.M., Barriopedro, D. *et al.* European temperature responses to blocking and ridge regional patterns. *Clim Dyn* **50**, 457–477 (2018). https://doi.org/10.1007/s00382-017-3620-2

Zschenderlein, P, Fink, AH, Pfahl, S, Wernli, H. Processes determining heat waves across different European climates. *Q J R Meteorol Soc* 2019; 145: 2973-2989.https://doi.org/10.1002/qj.3599

Zschenderlein, P. and Wernli, H.: How intense daily precipitation depends on temperature and the occurrence of specific weather systems – an investigation with ERA5 reanalyses in the extratropical Northern Hemisphere, Weather Clim. Dynam., 3, 391–411, https://doi.org/10.5194/wcd-3-391-2022, 2022.