EC1: Stephan Pfahl

As you have seen, while the two reviewers do not agree on the general recommendation how to proceed with your manuscript (at least referring to the first assessment of Rev. 1), they both have important questions and suggestions. Given that the main focus of WCD is on process understanding of atmospheric dynamics, I'd also find it important to extend your study beyond the documentation of a sensitivity and add some analysis of the underlying physical processes, as suggested by Rev. 1. In addition, to add the dimension of the decomposition approach (in addition to the underlying trajectory model), as suggested by Rev. 2, has some potential for additional insights, since, as also argued by this reviewer, it is not clear that your documented sensitivities would be similarly large when using an anomaly-based decomposition. To make your manuscript potentially publishable in WCD, I'd thus ask you to add further analyses and discussion of these two major points brought up by the reviewers.

Thank you for your guidance and for carefully considering our manuscript. We also appreciate the feedback provided by both reviewers. We acknowledge your recommendation and the specific suggestions raised by the reviewers. Specifically, we understand the importance of extending our study beyond the documentation of model sensitivities to include a deeper analysis of the underlying physical processes (as suggested by Reviewer 1), as well as discussing and contextualising the dimension of the anomaly-based decomposition approach relative to absolute fields (as suggested by Reviewer 2).

However, we think such analyses are out of the main goal of our current manuscript. As we have noted, given the widespread and continued use of pure-trajectory and dispersion models in heatwave research using absolute terms, we believe that our current sensitivity analysis provides useful information for the community by highlighting how the Lagrangian model choice can affect the resulting contribution of each process. Importantly, our study does not seek to establish which model class (pure-trajectory or dispersion) is most suitable, but rather represents a first step towards systematically investigating these discrepancies and their implications for heatwave attribution. Below we provide our rationale regarding the main suggestions of both reviewers:

1. **Regarding the first assessment of Reviewer 1**

In the assessment of Reviewer 1, it is assumed that FLEXPART (as a dispersion model) produces the correct result because it incorporates turbulence, convection, and sub-grid-scale parameterizations. While these features represent improvements over pure-trajectory models, we lack a definitive ground truth baseline to determine which model class provides an attribution closer to reality. As shown in the manuscript, our sensitivity tests, conducted by switching the FLEXPART parameterizations on and off, confirm that the turbulence parameterization drives the observed discrepancies. However, assessing which specific turbulence-related processes create these differences does not answer the core question: which model class should be used when applying the Lagrangian temperature anomaly decomposition? This is particularly true given that pure-trajectory models lack parameterizations entirely.

Nonetheless, as noted in our last response to Reviewer 1, we performed a targeted test using FLEXPART simulations both with and without turbulence parameterization, restricting the analysis to parcel tracks from two positions before crossing the PBL to two positions within it. The resulting budget still exhibits discrepancies in the contributions of adiabatic and diabatic processes. While this test illustrates part of the

effect that turbulence parameterizations have on the temperature anomaly budget due to the entrainment of air parcels into the PBL, it ultimately does not resolve the fundamental question that motivated our study.

2. Regarding the anomaly-based decomposition suggested by Reviewer 2

We understand that the reviewer is asking to perform an anomaly-based decomposition by computing the absolute contributions of each term during the event and for a climatological period, and then calculating the anomalies with respect to the climatological baseline. While there are long-term datasets for the dispersion model-derived air parcel trajectories, we lack such long-term datasets for the pure-trajectory models. Performing this anomaly-based analysis using both model classes would require considerable computing time. Despite this, it is difficult to confidently interpret anomaly terms when the analysis of absolute terms yields such different results. In addition, based on the findings of Mayer and Wirth (2025), the interpretation of the physical drivers of heatwaves depends fundamentally on the chosen analytical perspective, specifically, whether one analyses the absolute contributions of the processes or their anomalies relative to a baseline. On this basis, using an anomaly-based perspective addresses a different research question. Our study is focused on the discrepancies in the contribution of the absolute terms of the Lagrangian temperature anomaly decomposition from Röthlisberger and Papritz (2023).

On the other hand, Mayer and Wirth (2025), using the Eulerian tracer advection method, found that diabatic processes achieve the highest contribution to the PNW21 heatwave when analysing absolute terms. The contributions derived in our study using pure-trajectory models are aligned with this result from Mayer and Wirth (2025). This raises a new open question for the community: *Should we use the Mayer and Wirth (2025) method as a reference baseline to assess the Lagrangian temperature anomaly decomposition approach fed by pure-trajectory and dispersion Lagrangian models?*

3 Final remarks

Overall, our goal with the current manuscript is not to present a fully resolved answer, but to highlight this significant discrepancy to the community, thereby motivating the exact future validation studies and deeper theoretical analyses that all of us agree are necessary. In addition, we hope that our study generates more questions than answers and can serve as a useful basis for future work, helping to improve the robustness of heatwave attribution studies.

We also agree that our current study does not directly advance the understanding of atmospheric dynamics, but it highlights this important discrepancy that should be taken into account when the Lagrangian temperature anomaly method is applied to examine heatwaves.

As we noted in one of our previous responses to Reviewer 1, **the important issue is therefore not whether these results ultimately appear as a full research article, a shorter contribution, a technical report, an Ideas/Comment-type paper, or another format that you as Editor and the journal consider more appropriate.** What we consider scientifically important is that this methodological sensitivity and its implications are communicated clearly to the community. We would be entirely open to your view regarding the most appropriate format for doing so.

It should also be noted that we have highlighted in the response to both reviewers the changes that we will make in the revised manuscript if you consider that resubmission is appropriate.