

Weather Clim. Dynam. Discuss., referee comment RC1
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Comment on wcd-2022-44

Anonymous Referee #1

Referee comment on "Towards a holistic understanding of blocked regime dynamics through a combination of complementary diagnostic perspectives" by Seraphine Hauser et al., Weather Clim. Dynam. Discuss., <https://doi.org/10.5194/wcd-2022-44-RC1>, 2022

This is a nice paper which develops and applies three different perspectives to diagnose the development of a blocking event over Europe. This is a useful approach which helps to see how different processes and their associated theories relate to each other. The first two perspectives are linked through a common diagnostic framework centred on the PV equation (4), while the third is more distinct. The three methods are combined in a 'joint consideration' as opposed to a quantitative framework, but this nevertheless provides a fascinating, balanced and in-depth picture of the case study.

Overall, the paper is clear and well presented and certainly a useful contribution to the literature on blocking. The main conclusion that moist processes play an important role but that this is missed by some methods is sound and supported by the evidence. It is especially nice to see a focus on including and reconciling different viewpoints from the literature. The paper is a little long but I think this is unavoidable given the number of methods used, and in fact a few extra details in a few places might still be needed. I am supportive of publication after consideration of the following:

Major points:

1. Perhaps the most basic mechanism of forming an anticyclonic PV anomaly is through poleward advection and the beta effect. This is part of the barotropic term ($\mathbf{v}' \cdot \text{grad } q_0$) but this QB term is mostly discussed in terms of the downstream advection of existing PV anomalies. The role of this term in generating, not just re-arranging, PV anomalies could be diagnosed through calculation of the beta term, and should be at least discussed if not diagnosed. It was interesting to see in fig 13 that both the heated and non-heated back trajectories originate at lower latitudes than the final anticyclone, so that beta must play some role in generating the PV anomalies for both sets of parcels.

2. The methods differ fundamentally in whether they consider the cyclonic anomaly to be part of the block as well as the anticyclonic anomaly. I think the cyclone should probably be included given i) it's part of the regime structure used to define blocking here, and ii) it contributes to obstructing the westerly flow and causing some of the impacts outlined in the introduction. I don't think the analysis of methods 2 and 3 should be extended here to include the cyclone, but this limitation needs to be clearly discussed. It could also be summarised in the conclusions what drives the cyclonic part in this analysis.

3. The rationale for tracking of PV anomalies could be more convincingly justified. PV is conserved in the absence of diabatic/frictional effects but not PV anomalies (as seen from the beta effect), so why track the anomalies? There is a threshold for PVA, so arguably this method still misses some information on the initial origin of anomalies as well. The method is fine for this paper, as the single event has been studied carefully. But for future use it would be nice to see more validation of this new method, including sensitivity to the choices and/or parameters used.

Minor points:

1. The authors do a good job of selectively covering the plethora of suggested blocking methods in the introduction. But I think a mention of the methods of Noboru Nakamura and Clare Huang would be a good addition, especially since the authors claim to have gone further than others in combining adiabatic and diabatic processes, something which the Nakamura/Huang theory also attempts.

2. A few more details on the decomposition are needed - eg how exactly are v_{up} and v_{low} defined?

3. More justification is needed that the $(v_{low} \cdot \text{grad } q_0)$ term encapsulates the baroclinic effects. At face value, this seems a cruder definition than that of Martineau et al (<https://doi.org/10.1029/2022GL097791>)

4. Are all projections etc performed over the region shown in fig 2a?

5. line 237 - 10% sounds like a low tolerance here. What is the sensitivity to this?

6. Fig 5 was a bit too dense for me - could try fewer contours for the div term? And label that colorbar

7. It's interesting how the eddy fluxes come into these analyses, and not clear how closely the splitting/merging corresponds to the conventional picture of these. It might help to note for the eulerian analysis of this that the eddy fluxes are often diagnosed upstream of the existing block, to quantify their role in maintaining the blocking structure against the mean westerlies (Illari 1984). A crude quasi-lagrangian approach?

8. I struggled to understand the role of the radiation, especially as it seems to strengthen the trough in fig 6b, contrary to the idea of radiative damping. It seems to be a relatively uniform cyclonic influence across the domain. Is it due to bottom-amplified LW cooling acting to reduce stratification everywhere, or something else?

9. Could unify the names for the four periods between fig 11 and the text, for clarity.

10. Is the direct diabatic effect (section 4.2) only seen because the lower troposphere is excluded? (heating should give a negative PV anomaly above and a positive anomaly below)

11. p24: The case that the divergent PV tendencies are a moist impact seems a bit overstated. It seems to imply that all divergent tendencies reflect this, but the correlations are only consistent with 20-40% of the variance being shared.

12. Top of p28: could you make a link between the methods here, between the heated trajectories (lagrangian) and the divergence term (quasi-lag)? Seems consistent with the theory of Methven (<https://doi.org/10.1002/qj.2393>) that the role of the heating is not direct but to enhance ascent of low-level, low-PV air up the warm conveyor belt into the block.