Review of “Physical Processes Leading to Extreme day-to-day Temperatures Changes, Part I: Present-day Climate”

The work of Hamal and Pfhal investigates the physical processes of extremes in the day-to-day variability of near-surface temperature (DTDT) using the ERA5 data set. They use both composites maps and Lagrangian backward trajectories tracking to quantify the mechanisms for these extreme changes in temperature. Their main conclusion is that these extremes are mainly driven by changes in advection in the extra-tropics while the situation is more balanced in the tropics with important contributions from diabatic processes.

The paper is well written and the research question is clearly stated and interesting. The analyses carried out in the paper are careful, well explained and scientifically sound. I should say that the results are not particularly jaw-dropping – I would have guessed that advection was the main contributor of extremes of DTDT in the extra-tropics – but they are nonetheless interesting for documenting these mechanisms. I have some suggestions to improve the quality of the communications of the results and some additional analyses. Therefore I recommend major revisions at this stage, see below for my comments.

Major comments

1. Use of ERA5 and HadGHCND: I think the comparison between the DTDT variability in ERA5 and HadGHCND is problematic. As the authors show in their Figure 1, there are large differences between the two data sets that are probably not physical. The reason is likely because HadGHCND interpolates station data to construct a gridded data set which likely smooths out the daily variability (rather than lack of station coverage I think). In my opinion, this makes the HadGHCND data set particularly not suited for the study that you are doing here. That being said, it is true that the authors mainly compare the spatial patterns rather than the absolute values of sigma_DTDT between the two data sets. If you really want to compare the absolute values found with ERA5 with measured data you should probably go directly to station data. For these reasons, I would discourage to show the comparison with HadGHCND in the figures of the main text: the authors can include it in supplementary materials if they really want to do this comparison. In this case they should also discuss more the differences between the two data sets. Moreover, the rest of the paper does not use HadGHCND.

2. Statistical suggestions:

a. I think it would be interesting to show (at least for the grid points studied) the distribution of delta_T and the quantiles that you are selecting. In particular it would be interesting to see whether the distribution is symmetric. You could for example compute, in addition to its standard deviation, its kurtosis and show the corresponding map.

b. One question I had while reading the paper is how much the extremes of delta_T relate to extremes of T, in other words: do your warming/cooling events also correspond to warm/cool extremes? I think it would be super interesting to show how the extremes of delta_T are linked to the quantiles of T_t and T_t-1. For example, do extreme warming events happen because we start from a very cold quantile and we end up in the middle of the temperature distribution or do we start from the middle of the distribution and end up in the right tail ? The physical processes in these two situations are likely different.

3. **Comparison with climatology:** I find it really interesting that in Figure 4-5 and others the warming and cooling events seem the reverse of one another. As advection seems to be the largest contributor, it seems to me that extremes of sigma_DTDT happens as if this mechanism was switched on or off: warming events happen because the northward advection was switched off and vice versa for cold events. This leads me to my question

which is not unrelated to my previous comment 2.a., how are the dynamical situations that you identify unusual with respect to climatology ? Is it the starting point that is dynamically unusual or the end point ? To be more clear, it seems to me that you should probably do your composite maps also in anomalies.

4. Extremes of DTDT and fronts: the fact that advection is the main factor of extremes in DTDT in the extra-tropics is not super surprising and that is what I would expect because of the existence of atmospheric fronts (some may even argue that fronts are by definition extremes of DTDT). I am surprised that the authors do not mention at all these structures. Can you say a word about how your analysis and results relate to the literature on frontal structures ? Moreover, it seems to me that frontal structures are well identified in the climate variability literature as being the mechanism for day-to-day variability (e.g. Ghil and Lucarini (2020)), maybe you could also mention that in the broader context of your work.

Minor comments

1. Paragraph L49: in this paragraph you are mainly talking about hot and cold extremes, which are rather different from the extremes in DTDT that you are looking at. This may be confusing for the reader, please be more clear about how the extremes per se relate to the extremes of DTDT (see also my major comment 2).

2. For clarity, I think you should detail a bit more the terms in eq 1-5. In particular, equation 4 is not necessary to me and may be confusing. Moreover, you should explain what the approximation means in equation 3 (explain why this is actually a very good approximation and the errors involved are small because of the typical time scale of the seasonal cycle).

3. L126: can you detail a bit more why those choices were made, especially the date and time of the initialization of the backward trajectory.

4. Equation 6: this is more for my understanding: given that you are looking at air parcels close to the ground, how can the adiabatic contribution be anything else than positive ?

5. Figure 1: the colors scale in all panels is unfortunate. You are showing only positive, non-divergent values therefore you should not use a divergent color maps which is misleading for the reader. Also, because you compare between panels a,b and c,d, the values of the color map should have the same range. Finally, you should probably use the Robinson projection.

6. L149 and following: you are mentioning the “magnitude of sigma_DTDT changes”. I am not sure what this is referring to, if I understood correctly you should rather talk about the “magnitude of sigma_DTDT”.

7. L174: what are “the deep tropics” ?

8. Because you are studying land grid points only and their proportion varies a lot between the latitudes, I am not sure the zonal means in Figure 1 and following are really relevant: the reader can see by themselves that there is a marked latitudinal gradient of the quantities you are displaying. Also, do you have an explanation for why in the southern hemisphere the variability is much smaller than in the northern hemisphere for the grid points with the same absolute latitude ?

9. L205: “DJF warm events”: I would strongly discourage you to use this phrasing for the events you are studying because it is really misleading for the reader. You should rather talk about warming/cooling events.

10. Fig4:

a. Please define more precisely near surface temperature: is it T2M ?

b. I would suggest not to use absolute values for composite maps: first because there is still the seasonal cycle (how do you handle that by the way ?) and second because it is difficult to read and the sudden change of temperature from t-1 to t is not very clear. Maybe simply use anomaly maps and/or make a difference between the map at t and the map at t-1 ?

11. Figure 5 and alike: it would be clearer for the reader if you could indicate explicitly on the figure (not only in the legend) if those are DJF or JJA events.

12. L431: “To systematically investigate the mechanism driving DTDT extremes over the subtropics in the southern hemisphere during DJF and JJA, we select a specific location in Australia”: to me this sentence sounds self-contradictory, how can you systematically investigate if you look at only one grid point ?

13. The conclusions reached are based on the analysis of only some grid points at various longitudes/latitudes. Although I think the conclusions reached can probably be extended to the other grid points in the vicinity, I think the authors should be a bit more cautious in their concluding statements.

14. L531: “This dominant effect of advection also explains why the magnitude of DTDT changes is typically larger in the extratropics, where horizontal temperature gradients and wind velocities are larger compared to the tropics”: this statement is likely true but deserves more evidence.

References

Ghil, M., & Lucarini, V. (2020). The physics of climate variability and climate change. *Reviews of Modern Physics*, *92*(3), 035002.