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Interactive comment on "Attribution of precipitation to cyclones and fronts over Europe in a kilometer-scale regional climate simulation" *by* Stefan Rüdisühli et al.

Anonymous Referee #1

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This is a very timely paper on attribution of precipitation to main rain-bearing systems. It is not the first attempt to associated precipitation to various synoptic features, but this time it is more detailed and done using outputs of a convection-resolving model. I also like that results show annual and seasonal data for all 4 seasons, as there are important seasonal differences. The manuscript features excellent literature review and is well written.

I have relatively minor comments listed below. I am most concerned about attributing precipitation to high pressure systems. As the authors say, it is most likely associated with convection, so I made a few suggestions on that in the comments. Another sug-

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gestion is to add a threshold on the size of frontal areas, as there are many very small frontal features in the examples. Finally, I am interested if similar approaches are applied to ERA5(or other reanalyses), how the results will be different. The latter might be outside the scope of this paper, so I wish to see such comparison some time in the future.

Commnets:

158, 185: The 12 km domain is not significantly larger than 2.2km domain. Did you consider merging with ERA-interim? It might be particularly good for getting cyclones and high pressure systems right.

193-194: this not clear. Please explain better what you mean by allowing 20% of contours to cross the boundary before 'halting further feature growth'.

l.200: in the abstract it is said that local thermal fronts are removed, here you say that fronts are categorised at synoptic and local. Are local fronts removed then?

215: what is the threshold value on theta e gradient based on and why all values in Table 1 are whole numbers?

l.252: it is not clear to me how high-pressure systems are defined. One may think that you mean anticyclones (i.e. an area similar to cyclones with high pressure in the middle circled by a closed contour), but 'high pressure' systems in fig. 3 look confusing. In fig 3 (summer) the green area looks like the subtropical ridge (there are big and small white areas within green stippling - what do they represent?), in fig 5 (winter) I would suspect an anticyclone defined using the MSLP field. These systems need to be better described, both their identification procedure and physical meaning. There is a recent paper by Poujol et al. (2020) on a separation between convective and stratiform precipitation. It might be interesting to check if the precipitation within high pressure systems can be classified as convective using their approach. Discussion around lines 400 and 463 may benefit if you mention possible convective nature of

high pressure precipitation, that is prevalent in summer. Given the frequency of high-pressure 'components' (fig. S4), which cover 50% of your domain 50% of time in summer, these systems need to be explored in more detail.

fig.3: The example is very good, but I have numerous suggestions on plotting: The red outline stands for local fronts, while red filling (in slightly different shade) - for warm fronts. It would be good to use different colours. A bold black contour also circles the cyclone area, is that right? I think it is not mentioned int he caption. Blue filling of cold fronts is very similar to precipitation 0.2-1mm/h, please use different colours. I am not sure I can see red filling well for the warm front (it works better in fig. 5). Is warm front in fig. 3 a 'local' front, not synoptic? If this is the case then the separation between local and synoptic fronts is probably not working very well. It would be good to remind the reader that frontal systems within the high pressure system do not count as rain-bearing (i.e. this precipitation is attributed to the high pressure system only).

Fig. 3 makes me think that it would be good to have a threshold on the size of the frontal area to remove very small features.

l.412, Fig8 vs fig 9, high pressure precipitation: In figure 8 high-pressure precipitation is over the land only (with an exception for the Bay of Biscay), but for relative precipitation there is a large proportion of convective precipitation over the Mediterranean sea. Can you explain this?

Fig.9: I find it odd that cyclone and far-frontal precipitation are combined in this plot. I am not sure if this information is valuable. Is it possible to separate them?

l.438: Are you able to explain high amount of residual heavy precipitation comparable to, e.g., cold-frontal heavy rainfall?

Minor comments:

fig. 1 and possibly other plots: Please add lon/lat values.

p.2,l. 38: ", high-pressure systems, extratropical cyclones, fronts, orography ... con-

tribute to precipitation" - I'd avoid starting with high pressure systems as they not the main rain-bearing systems

p.2, l45; p3.l.78, 80: I think it should read "such resolution", "such attribution"

p.2, l47: I'd rather say "interplay between fronts and steep orography in producing precipitation"

p.2, l53-55: I doubt this sentence is needed

l.98: re-phrase 'on a continental-scale domain'; perhaps, 'for a continental-size domain' or "on a scale of a continent'

l.114: ' domain covering most of Europe' - I disagree, though it is hard to get the area by eye. Given the size of Eastern Europe (former USSR seems to be excluded from analysis) and Scandinavian counties, my feeling is that the domain covers roughly half of Europe.

l.124:"this attribution" replace with "their contribution"

133: 'can be found' instead of 'is found'

156: replace interpolate with extrapolate

165: "the features are interpolated back onto the original 2.2 km grid". I do not think this is the right way of describing it. My understanding is that you first create a mask based on 12 km field and then use it on 2.2 km scale.

392: change to 'selected'

l.558 and in thought the manuscript: I would avoid saying that summer precipitation is 'associated' with high-pressure systems, though technically this is what the paper shows. As you say, it is most likely associated with convection. I'd rather say that summer precipitation is often detected within high pressure systems.

fig.S2: Why do you need 'track frequencies', would simply 'frequencies' not be enough?

fig.S4: components of what?

âĂĺReferences:

Poujol, B, Sobolowski, S, Mooney, P, Berthou, S. A physically based precipitation separation algorithm for convectionâĂŘpermitting models over complex topography. Q J R Meteorol Soc. 2020; 146: 748– 761. https://doi.org/10.1002/qj.3706

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