Review of the paper: "Compound Hot-Dry and Cold-Wet Dynamical Extremes Over the Mediterranean" by De Luca et al.

Reviewed by Emanuele Bevacqua

The authors investigate compound hot-dry and wet-cold events over the Mediterranean basin, employing a novel method based on dynamical systems theory. They use different reanalysis products and find a tendency towards an increasing coupling between temperature and precipitation over 1979-2018. The paper is well written and pleasant to read. I find the use/introduction of this approach interesting given that it offers a novel perspective for studying compound events. New approaches are always welcome as they can challenge or confirm previous findings. I recommend publishing the paper, but also to address some comments that follow. All of the comments are, of course, meant be constructive.

A main comment I have is about the definition of hot&dry and wet&cold conditions. I understand that they are defined based on positive/negative seasonal anomalies of precipitation and temperature. Although also non-extreme values of the contributing variables can lead to extreme impacts, the employed anomalies may be be particularly small. Given that the authors link the study directly to compound events and associated risks in the Mediterranean area, I think that some considerations are required. The authors could repeat some of the analyses based on higher anomalies (see comment below). Alternatively, I would recommend modifying the text in several parts, including abstract (e.g., line 7) and title, to avoid giving the impression of referring to, e.g., hot (and therefore extreme) events. In general, when possible some more physical interpretation would be welcome to guide the reader.

Specific comments

L40, The paper from Manning et al. would definitely fit here (see also comment later): Manning C, Widmann M, Bevacqua E, Van Loon AF, Maraun D, Vrac M. Increased probability of compound long-duration dry and hot events in Europe during summer (1950–2013). Environmental Research Letters. 2019 Aug 29;14(9):094006.

L42, I would strongly suggest adding 2-3 sentences in this paragraph. You could explain, via examples and references, why wet-cold and dry-hot events can lead to impacts (e.g., wildfire, vegetation issues etc), i.e. why they are important.

From line 61 onward. Overall, the explanation is very easy to understand. However, would it be possible to add 1-2 equations to guide some type of readers?

L68, Does the persistence depend on any used threshold to define the close range dx (intorno) around Zeta_x? Or is it propriety of the system in Zeta_x that you somehow obtain based on some limits? Please, clarify.

L72, Also for the co-recurrence ratio: is this obtained based on (empirical) counting of the states and therefore it depends on the values dx and dx used to the define the close range

around Zeta_x and Zeta_y? I agree that a full description of the theory should not be given but, in my opinion, a few sentences to guide the reader are needed here.

“Compound dynamical extremes”, would it be better to use compound dynamical events? “Extremes” might be misleading.

L92, anomalies relative to JJA means

L96, Could you please explain why these slopes are preferred to usual linear regression. For example, would the trend in Fig. 1c-d be non-significant with a linear regression? Please, discuss this.

L110, Fig. 1a, Are you computing alpha for every JJA day and then computing the yearly average? Make this clearer, please (in the caption is not fully clear in my opinion).

L110, Guiding the reader to see what is happening in the (T,P) space would help here. For example, in summer, would you expect to find a similar trend using Tmin and P (or, in winter, Tmax and P)?

L112, Would in any way carrying out the analysis after detrended the time series of the temperature help to better understand the physical drivers of the trends?

L 120, is there a correlation between co-persistence and alpha?

L121, how are, in this regional case, hot and dry days subsampled?

Section 4.1, Do also the univariate persistences show a similar seasonality? If so, is it possible to interpret this in relation to the seasonality in alpha?

Section 4.2 and the following sections. The authors could consider whether moving these results before the trends would help or not. Being aware of what alpha depicts from a physical point of view may help to interpret the trends more easily.

L141 (paragraph)

1) In general, a discussion on why one would expect to capture anomalies would be important to help the reader.
2) I understand that the anomalies are computed relative to the seasonal mean, please specify it.
3) To strengthen the conclusions, you could highlight that small anomalies are expected over the sea due to water inertia, even during heatwaves.
4) Overall, the SLP field picked up by high alpha values in winter appears associated with a more defined atmospheric configuration compared to summer. Is it possible that you pick up different weather circulations within the subsample of extreme alpha in summer?
   - I see you have stippling in Fig. 4. How large is the average anomaly during days with large alpha compared to the standard deviation*? *computed based on the daily anomaly data.

- How do these maps change when using, e.g., the 95th percentile to define extreme alpha?

5) L146, The latter correspond…: Personally, I would rephrase given that although the significant anomaly is all associated with the large-scale component of the precipitation, also the convective part is relevant. The reasoning in the next sentence would still work, maybe saying these anomalies are *mainly* linked to SLP.

L158, The sentence is correct. But it suggests that these events can occur everywhere over the analysed domain, while, especially the P anomalies, suggest that this is the case mainly over the eastern domain and along the Italian areas exposed to cold-air advection from northern Europe.

L160, I understand that hot-dry and cold-wet events are defined based on positive/negative anomalies from the seasonal average. Would the main conclusions be similar if using larger anomalies to define, hot/cold and wet/dry conditions? For example, one could use +/-2 standard deviations from 0 to define larger anomalies.

L167, Could you relate to the numbers above, i.g., does this also imply that also the values 84% and 77% are significantly large?

L162, How are these numbers computed: Are all CDE days and grid points pulled together? Please, clarify.
L168, consistently with Fig. 4f, the distribution of the precipitation is peaked around zero in fig. 5d. I am wondering whether (maybe for future work) the authors would see any added value in focussing some of these statistics only over the eastern part of the domain, where the framework is able to better capture anomalous conditions. If so, this could be discussed.

Section 4.4, It is a bit difficult to read the values in fig. 6 given that the palette has continuos values. Aren't these values depending on the percentiles (here 90th) used to define the CDE events? Therefore, the reader should be helped to interpret these numbers. They should be compared to what expected under a certain null hypothesis. For example, one could easily compute the probability of getting concurrent CDE and hot&dry days assuming that the CDE events are randomly distributed during the year (if this is a reasonable assumption).

Discussion: Could you add 1-2 sentences about the expected sensitivity of the results from the size of the analysed domain? This is relevant for the reader...

L190, Do you think that re-computing the trends in the two metrics obtained based on maps of (1) land surface only and of (2) sea surface only could somehow allow for speculating more safely about this? Or, more in general, could this allow for disentangling a higher signal of the increasing coupling on land?

I understand that the trends you found in the regional coupling can have different meaning depending on the areas of the domain so I understand that they should be interpreted bearing this in mind. Could you discuss more explicitly on this from an impact perspective?

Around L205, I would suggest to interpret and discuss the results also in relation to results found by Manning et al. (paper cited above).

L215, see my main comment about the definition of hot days.

The authors could consider expanding the discussion, very briefly, to highlights the potential benefits of their approach for the part of the compound event community that is focussing on impact assessments.

More technical comments

L10, discussing first the winter results may allow avoiding some repetitions.

L17, add space

L19, I would probably start talking of atmospheric circulation changes which are more intuitive than “dynamical changes” for a non-expert reader.

L20, may expect based on?

L27, an increase in “daily” or “episodic” precipitation extremes?

L56, “[...]. The metric theta^{-1}...”

L79, each daily timestep

L80, with -> characterized by…; L81, could be written slightly better

Fig.1, caption, L4, 5 year centered moving [...]

L200, Please, check that it is ok. I assume you did not talk of Tmax *and negative P* anomalies on purpose.

L 211, it is probably more correct to write “concurrent cold spells and heavy…”

L212, “e.g” in the parenthesis

L212, “accordance” a better word? It might not look in accordance with the decrease found int the other studies.

Well done. Best regards.