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Discussions

Interactive comment on "Relative importance of increased atmospheric CO_2 concentration and local moisture deficit to hot extremes" *by* Ajiao Chen et al.

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I have taken a bit more time than I normally do to review this work, because the study is interesting but also because I felt there might be some potential issues with the analysis that I wanted to get clear. The manuscript by Chen and co-workers focusses on the occurrence of hot extremes and their relation to global warming on the one hand, and local soil moisture conditions on the other. This is relevant because both factors have been shown in previous studies to play a role in the occurrence of, and trend in, hot days. Simply put, the authors analyze where the correlation between heatwave days and global CO_2 levels is higher, and where the correlation with local soil moisture deficit

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Discussion paper

is higher. The main question for me as a reviewer is whether such a comparison makes sense, and is fair.

I feel there are several issues with this approach, related to the variables selected for the analysis, as well as with the data used to calculate the correlations. Firstly, the selection of yearly-average, global CO_2 levels is somewhat arbitrary. Yes, they drive global warming, but nobody would claim that the yearly variation of CO_2 would directly influence hot days at any particular location. The link is simply too indirect and weak, since it depends not only on how CO_2 levels influence global temperatures, but also circulation. CO_2 is also only one of the greenhouse gasses. In a way, it would be more logical to use global average temperature deviations instead, since these at least reflect the effect of ENSO and other climate variability that is known to affect the occurrence of hot extremes. But even there the weak is link, since in many regions the year-to-year variability in heatwaves is much more closely linked to indices such as ENSO, NAO etc. than it is to global CO_2 or local soil moisture. Again I am not talking here about the fact that heatwaves increase with global warming, and that this increase correlates with global CO_2, but the point is that the absolute value of the correlation coefficient is meaningless and should not be compared to other correlations because it results from arbitrary choices.

A second problem is caused by the data used. From what I was able to find about the GRACE TWS dataset used, it seems that the different timeseries have been detrended. This is problematic in the view of the main research question, because any temporal trend in storage due to climate change will now be attributed to changes in CO_2 only. This also shows that CO_2 and soil moisture impacts will be difficult if not impossible to separate from observations only, since the two are not independent. A second problem is that the different decomposed signals should be interpreted with care. Even if they do reflect soil moisture at different depths as the authors claim, it will be unlikely that any storage with response timescales of several months will significantly impact energy balance partitioning at the land surface, and air temperature. In case of the significant correlations found by the authors, Occam's razor should be applied first: the more simple explanation is that both are affected by persistence in the atmospheric forcing signal due to persistence in atmospheric circulation. Only is this can be excluded as explanation should the correlation be interpreted as the result of direct soil moisture effect on air temperature.

In conclusion, I believe the separation between CO_2 and soil moisture effects on hot extremes cannot be done from correlation analysis on observations along the lines of the analysis presented here, but would require dedicated experiments with coupled climate models. Since in my view the conclusions of this work on the relative importance on both processes are not sufficiently justified by the evidence presented, I have to conclude that the current version of this work is unfortunately not suitable for final publication in HESS.

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