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Hydrology and Earth System Sciences
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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Here I want continue the discussion on the use of dominance analysis, and the variables used in the analysis. The authors provide the example of groundwater, where the technique was used to study the relative impacts of monsoon rainfall and pumping on the groundwater table dynamics. This example actually illustrates my point fairly well. In case of rainfall and pumping, nobody would argue against that these are the two main factors that control groundwater table dynamics in a rather direct, predictable and proportional way. This however is not the case when considering impacts of global CO2 and local soil moisture deficits. The link between global CO2 is

indirect, and opposite to the groundwater example nobody would argue that there is or should be a direct link between global CO2 levels and HWD at any particular time and location. The same is true for soil moisture. Soil moisture is known to contribute to heatwave temperatures (e.g. Miralles et al., 2014, doi:10.1038/ngeo2141), but much of the local heat actually comes from advection driven by circulation patterns (e.g. Rasmijn et al., 2018, doi:10.1038/s41558-018-0114-0 and Schumacher et al, 2019, doi:10.1038/s41561-019-0431-6). In spite of the strong correlation, the contribution of local soil moisture to heatwave temperatures is important, but by no means dominant. The problem here is the classical pitfall that correlation is not causality. Soil moisture and temperature will be strongly negatively correlated in many regions simply because synoptic conditions leading to high temperatures (clear skies) are the same as those enhancing soil drying. But this does not mean that dry soils cause the high temperatures. In regions that are wet enough for ET not to become limited by soil moisture even during hot extremes, one would not expect soil moisture to impact temperature. By only using simple correlation, these regions will incorrectly be flagged as regions where soil moisture impacts temperature. To circumvent this, more complex coupling metrics have been developed that look for instance at anomalies in the surface energy balance (see Miralles et al. (2012) doi:10.1029/2012GL053703 among many others). The main factors in determining year-to-year variability of HWDs, like circulation indices, are not considered here. By only looking at correlation between variables that only weakly and indirectly impact HWDs, statistically significant results might be found, but that doesn't mean that they also provide new or meaningful insights.

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