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The outstanding 2019 Heatwaves in Central Europe – driving mechanisms and soil-atmosphere feedbacks

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In the current study, we analyzed the two outstanding heatwaves (HWs) that affected Europe in summer 2019. The events occurred in late June and late July and were record-breaking, although peak temperatures were observed in distinct areas. During the June HW the highest temperatures were recorded in SE France, when the country registered for the first time temperatures above 45ºC. The July HW made thermometers cross the psychological barrier of 40ºC for the first time in Belgium and the Netherlands, breaking all-time records in widespread areas of Central Europe.

We detected that a subtropical ridge fostering warm advection from lower latitudes was a common feature for both HWs. However, we have also found distinct mechanisms shaping the two HWs. While the June HW was predominantly characterized by the intrusion of a vertically homogenous air mass of Saharan origin, surface processes and upward transport of sensible heat were pivotal for the July HW. Our results suggest that the intensity and extension of the June HW contributed to soil desiccation, which together with the persistence of dry and clear sky conditions during early July led to an amplification of the surface temperature anomalies during the late July HW. This is supported by a flow analogue exercise, showing amplified surface heating for flow analogues of the July HW when they are preceded by short-term dry soil moisture conditions, like those caused by the June HW. In turn, we show that, in agreement with the long-term regional warming, soil desiccation during the June 2019 event was larger than it would have been in the recent past (assessing 1984-2018 versus 1950-1983). Finally, we compared the spatio-temporal distribution of summer temperature for 2019 and the previous record-breaking summer 2003. Results show that an outstanding warming fingerprint (circa +1.5ºC in summer daily maximum temperatures averaged over Europe) has been superimposed on the relatively larger magnitude of the August 2003 HW (with respect to the climatology at that time), thus explaining the exceptionality of the record-breaking values observed in 2019.

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