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Nonlocal soil moisture effects during European heatwaves

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It has been shown that European heatwaves can be significantly intensified by dry land surface conditions. While local temperature intensification through soil moisture feedbacks are well understood, the role of nonlocal soil moisture conditions has yet to be studied in more detail. Studies suggest that through modification of the atmospheric circulation, soil moisture conditions can enhance local temperatures and even evoke a remote temperature response.

In this study, we analyze how nonlocal soil moisture – atmosphere feedbacks contribute to the development of high temperature extremes during a seasonally persistent European heatwave. We use a CESM-based global circulation model framework described in Merrifield et al. (2019), in which near-identical heatwave-inducing atmospheric circulation patterns encounter different land surface conditions. In one ensemble the whole atmosphere is constrained, allowing only local temperature intensification by the land surface. In the other ensemble only the upper atmosphere is constrained, enabling the land surface to modify the atmospheric circulation below 300hPa.

To understand what variables and processes contribute to regional heatwave intensification in some members and damping in others on a daily timescale, a refined spatio-temporal analysis of the data set was performed. We find that local daily temperature spread across ensemble members amounts to 5°C in the ensemble with unconstrained lower atmosphere, which is 4°C more than in the ensemble where the whole atmosphere is constrained, highlighting the importance of nonlocal land – atmosphere interactions. We identify atmospheric pathways through which the land surface state in one region affected the intensity of the heatwave in another region during the initiation, peak, and decay phases of the event. These heatwave intensification storylines may help to inform seasonal prediction and improve preparedness for future European heat events.