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Investigating the relative role of local and atmospheric processes governing European summer heatwaves in the UPSCALE modelling campaign

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Warm dry summer weather over Europe is due to the prevailing synoptic conditions, but actual heatwaves in particular regions also depend on the land surface conditions and interactions with the atmosphere, which may occur over longer time scales. This continuum of land-atmosphere interactions depends principally on evaporation from the soil and transpiration from plants, which cools the surface and so provides a negative feedback on surface temperature. The amount of evapotranspiration is controlled by the amount of soil moisture available, which in turn depends on previous precipitation, so that a dry winter or spring will often lead to a heatwave the following summer.
The SWELTER-21 project is investigating European heatwaves by using simulations from the Met Office Unified Model (in its GA3 formulation), run at high resolution (UPSCALE campaign) and using the JULES surface scheme. The overall project aims to quantify the key processes and feedbacks which link the synoptic conditions, surface temperature, precipitation, soil moisture, soil evaporation and plant transpiration.
The model simulations used in this study were free-running atmosphere-only, forced with OSTIA SSTs for a period of 27 years (1985-2011) and current climate atmospheric forcing. This experimental setup implies that the simulations do not reproduce the actual heatwaves which occurred during this period, but instead produce a large climatological database of different types of heatwaves over different regions. The model heatwaves can then be compared and contrasted with summers without heatwaves, by calculating the anomalies and the correlations between anomalies across Europe.

Some of the model heatwaves are only correlated with the synoptic conditions, i.e. soil moisture and overall evapotranspiration are similar to or even above the 27-year climatology, and these are principally over Eastern Europe and European Russia. In contrast, other model heatwaves are also correlated with significantly reduced soil moisture and reduced evapotranspiration compared to the climatology, and these occur principally over Western Europe. As expected, the model simulations show positive correlations between evapotranspiration and available soil moisture, and, as temperature increases, transpiration is reduced (due to plant response) while evaporation is increased from moist soil in Northern Europe but is reduced from dry soil in Southern Europe.